

> FLOODED
PARADISE
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> GATEWAY TO
THE STARS
We visit an arctic spaceport

> HEAD
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Impossible surgery or life saver?

AUSTRALIAN

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Rogue Planets

Lost in space, could these
wandering worlds
be home to life?

+ SOLAR
STORMS!
WILL THE SUN DESTROY
OUR CIVILISATION?

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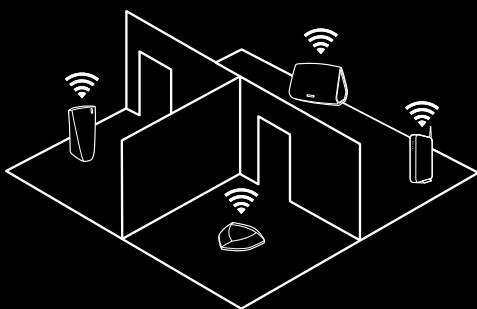


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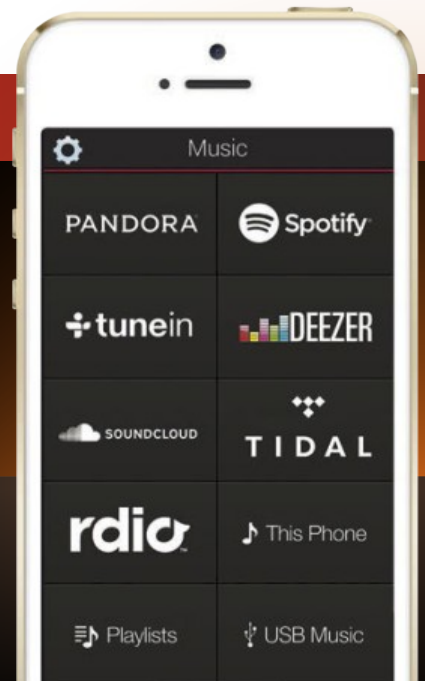
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THE SCIENCE ILLUSTRATED CREDO

We share with our readers a fascination
with science, technology, nature, culture
and archaeology, and believe that through
education about our past, present and future,
we can make the world a better place.

Learning From Our Children



When I started school in the early 1980s, there were certainly plenty of academic papers and even a few pop-scientists out there pointing out the parlous state our planet was getting itself into. Indeed, Paul Erlich's kind-of-wrong-but-only-about-the-timing book *The Population Bomb* was published in 1968. My mother took me, as a baby, to hear him speak.

But despite this, 80s schoolkids weren't taught about the environment. We weren't taught that humans have the capacity to destroy the very land we rely on to sustain us. In the early 1980s, the focus was on nuclear war (more so in the US than here in Australia) and on understanding our history. And on the upcoming Bicentennial.

In contrast, my own children have already been exposed to a huge range of exercises and lessons on, albeit simplified, ecology and environmentalism. More subtly, there's a general skew to the way they are taught that ingrains into them: the planet is vulnerable, and we should respect it. And through that respect comes repair and maybe even salvation.

It's a rare sense of hope that stands in contrast to most of the daily papers. And it makes me wonder how this generation - which I'm not sure even has a name yet - will behave once they come into adulthood in the late 2020s. My son Sam, for instance, will be 18 in 2026. That's a positively science-fiction date as far as I'm concerned, but to him 2026 will be the year his life just gets started.

When this generation goes out and gets jobs, joins university activist groups, plays out that eternal drama of how they are 19 years old and

nobody in the history of the universe has ever experienced what it's like to be 19 and adrift in a huge and uncaring world, I think the results will be... interesting.

The difference in the world between the arrival of my baby-boomer parents (born in the late 1940s) and my own birth in 1977 was pretty minimal. Especially if you compare the difference between, say 1975 and 2015. Heck, I didn't even have on-demand video entertainment until we got a VHS deck in 1986. There was no GPS, no internet to speak of, and only a vague sense that we all lived together on one planet with limited resources.

All the things we curse about modern childhood - the screens, the constant connectivity, the social media negativity - at least give this generation a sense of connectedness. And THAT, more than any sad documentaries about tuna, is what will make them different to us. A new kind of person who perhaps consumes less, demands less, travels more and treads a little lighter on the Earth.

Paul Erlich's book was proven "wrong" because the USA did not collapse in the late 1990s as millions starved. He did not predict the great "Green Revolution" of the 1970s that saw agricultural yields double or even triple. Erlich underestimated the power of technology. He's back on the pundit circuit again, still convinced we're headed for collapse. But this time, he's underestimated the positive feedback loop that technology can have on the social behaviour of people for whom the internet is not a new-fangled thing. It just is. I'm quietly optimistic for the youngest generation. Just so long as all us old folks don't ruin it for them.

Anthony Fordham

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THINGS WE LEARNED IN THIS ISSUE

- + The universe is full of **ROGUE PLANETS** that could be stranger than anything we can possibly imagine.
- + A new **ARCTIC SPACEPORT** will change the space industry and maybe send humans to other planets.
- + A **HEAD TRANSPLANT** isn't just possible, it's probably inevitable!
- + The **PANGOLIN** has a tongue longer than its entire body, anchored to its hip.



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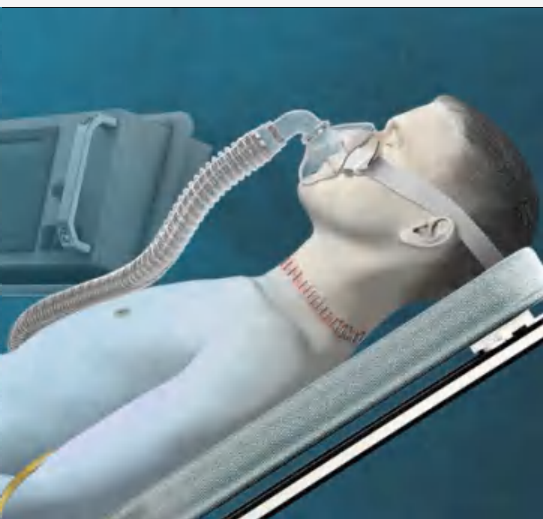
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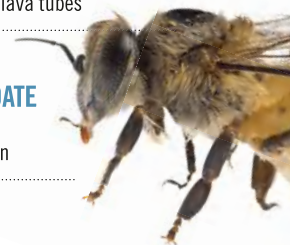
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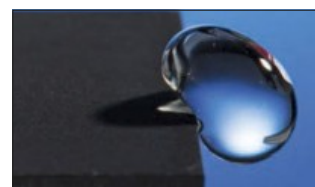
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MEGAPIXEL

GEOLOGY





VOLCANIC ERUPTION DRILLED A TUNNEL ↓

In 1792, Sicily's Mount Etna erupted, and lava continued to flow for more than a year. An 1,100-m-long and 300-m-deep tunnel provides us with a geological snapshot of this violent chapter in the life of the volcano. The Grotta dei Tre Livelli tunnel system formed when the surface lava hardened, but lava inside continued to flow, creating this tunnel. Long grooves in the cave roof still show how the lava flowed over 200 years ago.

ROBERTO MONTI

MEGAPIXEL

GEOGRAPHY



SCIENCE ILLUSTRATED

A high-resolution satellite image of a mountainous region in the Alps. A light-colored, winding road snakes across the steep, green and brown slopes. The road features several sharp hairpin turns. The terrain is rugged, with visible ridges and valleys. In the upper right corner, there is a text box with a title and a paragraph of text, followed by a small credit line.

RISKY MOUNTAIN STAGE ↓

Motorists and cyclists must master 75 nerve-wrecking hairpin bends if they want to cross the Stelvio mountain pass in Italy - some of which appear in this satellite image. Located 2,757 m above sea level, the pass is the second highest in the Alps. The road, used as part of the Giro d'Italia cycling race, is only open in the summer. Originally built in 1825, the route has changed little in the years since.

BENJAMIN GRANT/SATELLITE IMAGERY COURTESY OF DIGITAL GLOBE/DAILY OVERVIEW

Editors: Karen Grubbe

3D-MAPPING EARTH'S TURBULENT INTERIOR

A new model helps scientists predict earthquakes.

GEOLOGY While we can still only dream of travelling to Earth's interior, an American team of scientists has done the second-best thing. Aided by one of the world's fastest supercomputers, Titan, they created a 3D model of Earth's 2,900-km-deep mantle.

From seismographs throughout the world, the scientists collected data

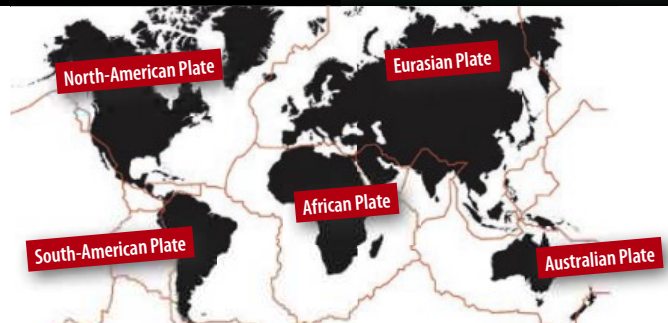
about approximately 3,000 Richter 5.5+ earthquakes. Subsequently, Titan was fed the information, and the supercomputer used its impressive calculating power to combine the data and produce the 3D model. The 3D map shows the exact locations of Earth's magma chambers and the places in which tectonic

plates collide, where one is forced under the other.

This knowledge is useful to scientists, who learn which areas to keep an extra eye on. Consequently, the model paves the way for scientists to predict earthquakes and volcanic eruptions more accurately and at an earlier date.

QUAKES BEGIN WHERE PLATES COLLIDE

Earth's exterior consists of inflexible plates which drift about on the soft, warm mantle. The plates are constantly in motion, and when two of them collide, one plate is forced under the other, or drags alongside its neighbour. As a result, large amounts of energy are released in the form of seismic waves, which become earthquakes at the surface.



AMERICA'S FIRST CASINO FOUND IN CAVE

ARCHAEOLOGY Long before Las Vegas, the Americans were experienced gamblers, according to an archaeological excavation of a cave on the shores of the Great Salt Lake in Utah.

Scientists from the University of Alberta have found a wealth of approximately 800-year-old dice, gaming pieces, and tiny animal bones that were probably used in a type of "guess which hand" game. In the old gambling den, scientists have also unearthed hundreds of

animal skin moccasins for both children and adults. Archaeologists assume that they were used in a game about identifying the moccasin in which an object had been hidden.

The gamblers probably belonged to the Promontory people, who lived in caves by the lake in the late 1200s. The cave has not yet been fully excavated, and scientists expect to find more than 10,000 gambling pieces.



4,500 years. Age of a skeleton from Siberia, in which scientists have found evidence of cancer that has spread throughout the body.

WAVE VELOCITY REVEALS HAZARDOUS PLACES

Seismic waves from earthquakes travel at different speeds, depending on the material they pass through. The waves travel fast in a dense, cold rock layer and slowly in a warm magma chamber.

MAGMA CHAMBERS

The red and orange swirls indicate warm rock, in which seismic waves travel slowly, such as magma chambers.

NORTH AMERICA

PLATE COLLISION

The blue and green swirls indicate cold, dense rock, in which seismic waves travel fast, or where a plate interacts, destructively, with another one.

Parasite

Host

Scientists found a tongue worm on a 425 million year old crustacean.

ANCIENT PARASITE FOUND ON ITS HOST

PALAEONTOLOGY 425 million years ago, a parasite invaded an ostracod, and once it attached, the parasite never let go. Now, an international team of scientists have discovered the parasite fossil and its host in a rock layer in Herefordshire, England.

The parasite, which is just four mm long, is very well-preserved and belongs to a new species of the thread-shaped tongue worm. The parasite's modern relatives live in the airways of terrestrial vertebrates and can grow up to 13 cm long.

News Flash!

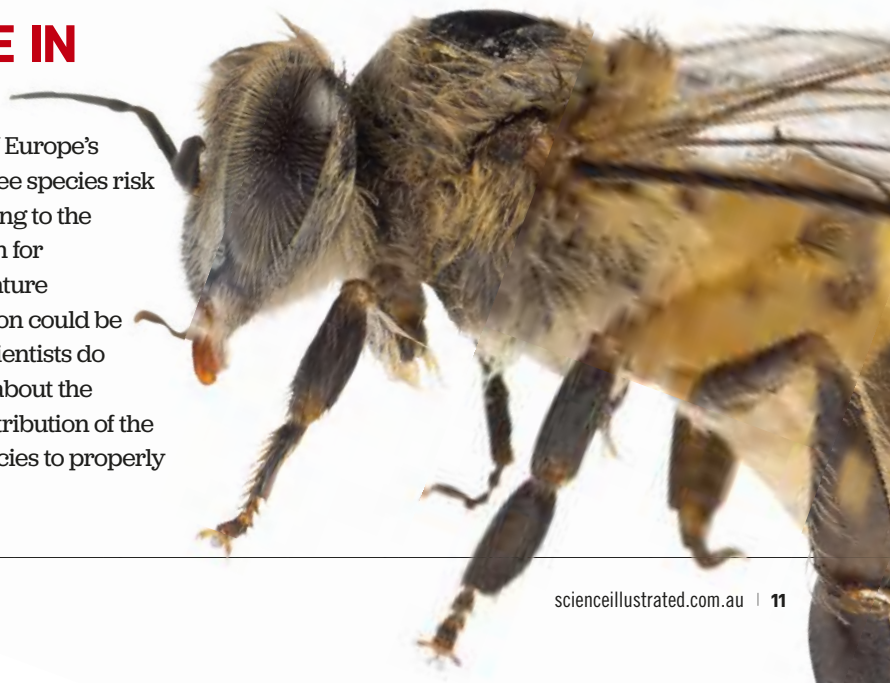
LIGHTNING RESHAPES ROCK

Scientists have studied rock and discovered that lightning can alter its structure. Lightning strikes caused such pressure that a crystal layer beneath the surface had become disfigured, ending up as shock lamellae with a different atomic structure.

BEES DIE IN EUROPE

About one in ten of Europe's some 2,000 wild bee species risk extinction, according to the International Union for Conservation of Nature (IUCN). The situation could be even worse, but scientists do not know enough about the behaviour and distribution of the majority of the species to properly estimate the risk.

SHUTTERSTOCK

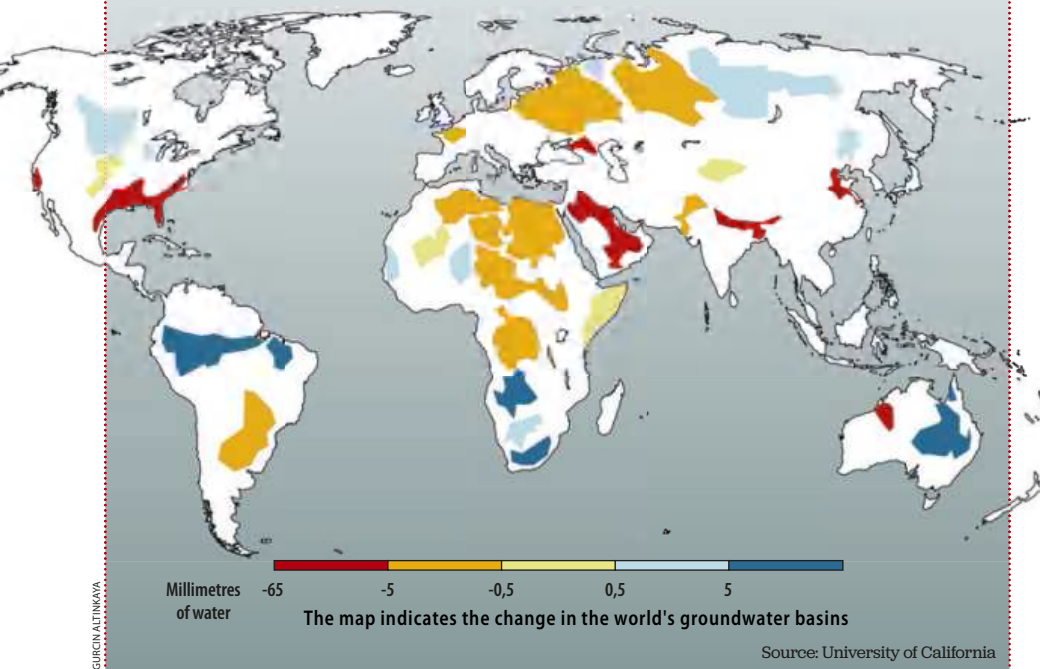


Earth's water reserves shrink

CLIMATE The world could be running out of water. More than 50% of the globe's 37 biggest groundwater basins are being drained at a worrying speed, and one third are under critical pressure. Those are the

dry facts, according to experts, who base their results on data from NASA satellites.

The scientists warn that climate change on Earth and its growing population will only make things worse.

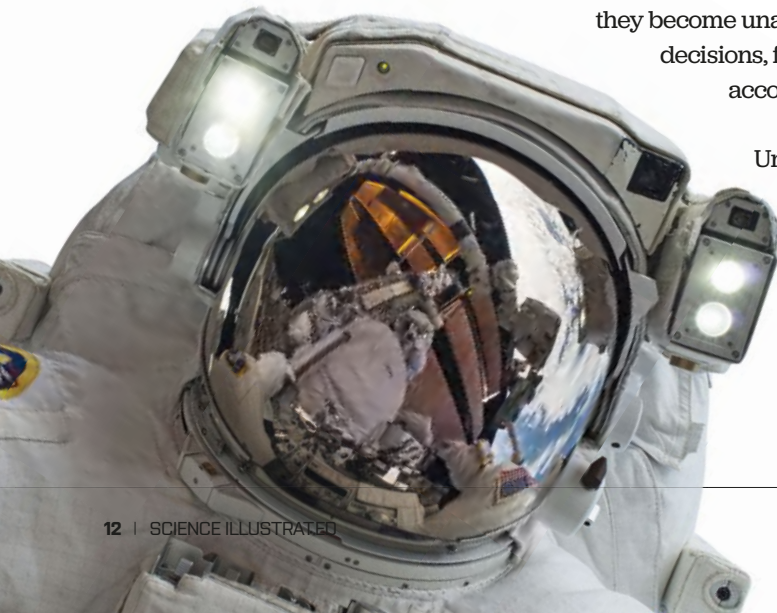


RADIATION MAY HARM ASTRONAUTS' BRAINS

There is bad news for future Mars travellers: The cosmic radiation outside Earth's atmosphere is so intense that it harms the brain cells of astronauts, so they become unable to make complex decisions, focus, and remember, according to experiments carried out at the University of California.

Mice were subjected to radiation resembling cosmic radiation, and as a result, they developed a type of dementia.

NASA



Strange but true!

3D printed wooden chair

Swedish scientists are the first to have 3D printed a small chair of plant fibres (cellulose). The scientists mixed tiny fibres into a water gel. After the printing, the scientists froze the chair, removing the water.



PETER WIDING

High-pitched sound causes cat seizures

High-pitched sounds such as the clinking of coins can trigger seizures in cats, a team of scientists discovered after examining 96 cats. The condition, which has been named the Tom and Jerry syndrome, causes body stiffening and loss of consciousness.

Voters like deep voices

Politicians with deep voices get more votes. In a new study, a team of scientists made a group of 800 test subjects choose between two candidates. The two of them uttered the same words, but the frequency of the voice was gradually changed. Deep voices won 60-76 % of the votes.

RED BLOOD CELLS FOUND IN DINOSAUR

A powerful microscope has revealed both red blood cells and collagen in dinosaur fossil.

PALAEONTOLOGY When scientists from the Imperial College London decided to take a closer look at 75-million-year-old fossils from a predatory dinosaur, they were in for a surprise. In the ancient bones, they found remains of structures, which are probably red blood cells and collagen. The latter is a protein, which helps produce bones and tendons.

The sensational discovery was made using a special microscope, a

scanning electron microscope, which illuminates the fossils with electrons instead of light, producing large blow-ups. The discovery of the possible blood cells and collagen will allow scientists new insight into the lives and evolution of dinosaurs.

Scientists have already found remains of soft tissue in exceptionally well-preserved dinosaur fossils, but the new find was made in bones that had not been properly preserved.

PREDATORY DINOS

PERIOD: Lived 65-230 million years ago.

DIET: Meat.

GAIT: The dinosaurs ran on their powerful hind legs. Their forelimbs were more delicate.

SIZE: Some were the size of chickens. Others, such as the T. rex, weighed 6-8 tonnes.

EXCEPTIONAL NEW FIND

BLOOD CAN ANSWER QUESTION

Structures presumed to be blood cells have been found in a claw from a predatory dinosaur which lived in Canada 75 million years ago. Scientists hope that the size of the cells can reveal if the dinosaurs were warm- or cold-blooded.

COLLAGEN



RED BLOOD CELLS



SERGIO BERTAZZO/IC & SHUTTERSTOCK



A new miniature drone without a motor flies at a speed of 74 km/h.

SWARMS OF MINIATURE DRONES WILL TRACK THE ENEMY

TECHNOLOGY The US navy has developed a small drone to be used for anything from listening for submarines to tornado monitoring.

The drone, which is meant for one-time-only use, has no motor and is

almost silent. The drone is launched from a plane and then follows a pre-programmed course.

Drones are excellent flyers. In a test, they were dropped at an altitude of 17,500 m, landing just 4.5 metres from the target even at a speed of 74 km/h.



NAVAL RESEARCH LABORATORY



LOCAL FOCAL POINT

The Philippines



100 new marine species discovered

The waters off the Philippines are a paradise for scientists searching for new species. More than 100 so far unknown marine species such as tunicates (pictured) have been discovered by scientists from the California Academy of Sciences, who explored both deep and shallow waters.

CALIFORNIA ACADEMY OF SCIENCES

MOLECULES CLOSE TO ABSOLUTE ZERO

Using laser light, American scientists have chilled molecules to an all time low temperature of 500 nanokelvins, corresponding to a smidgen - or 500 billionths of a degree - above absolute zero (minus 273.15 °C or 0 degrees Kelvin). At this temperature, all molecules stand completely still.

JOSE-LUIS OLIVARES/AMT



NASA



Saturn is surrounded by a huge ring located six million km away from the planet.

SATURN'S NEW RING IS GROWING

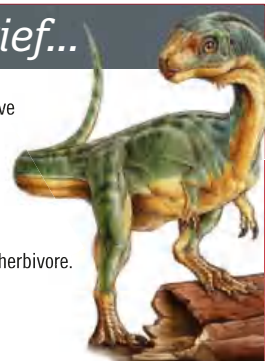
ASTRONOMY In 2009, astronomers discovered that apart from the known rings, Saturn is surrounded by an outer, almost invisible ring, which is considerably bigger than any of the others. Scientists have now realised just how huge the ring is: almost 7,000 times bigger than Saturn itself, and 30% bigger than astronomers expected.

NASA's infrared WISE telescope has mapped out the ring, which has been named the Phoebe ring. The new, infrared images reveal that the ring begins six million km from Saturn and stretches to a distance of at least 16.2 million km from the planet.

In Brief...

Scientists have discovered a 145-million-year-old relative of the Tyrannos which was a herbivore.

GABRIEL LIO



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FINGERTIPS

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WEIGHT

The artificial hand only weighs 400 g, but it is strong enough to carry up to 45 kg.

MOBILITY

The fingers can move independently of one another and have 14 grips and positions.

MATERIALS

The prosthesis is made of materials such as aluminium, which are both light and extremely durable.

NATURAL LOAD DISTRIBUTION

When the person carries heavy loads, the prosthesis shifts the weight to the wrist, so it does not feel uncomfortable.

Artificial hand fits all

The artificial hand, which has been named Bebionic, comes in different sizes and shapes, allowing it to be adjusted to several body sizes.

THE MUSCLE-CONTROLLED ROBOTIC HAND

A new artificial limb with 14 different grips and positions is controlled by signals from the muscles.

MEDICINE The British artificial limb manufacturer Steeper has developed a life-like artificial hand, which allows its owner to carry out delicate motor functions and grip things with unprecedented accuracy.

The extremely sophisticated prosthesis consists of 337 mechanical parts and functions like a real hand. The prosthesis features no less than 14 grips and positions, in which the fingers move

naturally and accurately, opening and closing around things.

The life-like limb, which was developed over a period of 7 years, is a myoelectric prosthesis that is controlled by the muscles. Electrodes on the muscles detect the brain's commands and send the data to the prosthesis' integrated computer, which translates the signals into finger motions.



YOUNG WOMAN GETS NEW HAND

29-year-old Nicky Ashwell was the first woman in the UK to get the new hand prosthesis. The woman was born without a right hand and previously had a cosmetic prosthesis, which could not move. Thanks to the bionic hand, Nicky Ashwell can now tie her own shoe laces and use both hands to write using a computer keyboard.

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Why do clouds light up at night?

I sometimes see luminous clouds long after sunset. Where does the light come from?

You see these “noctilucent” clouds, because the Sun still shines on them, even after it has disappeared below the horizon. This is only possible when the clouds are located at an altitude of about 83 km - almost in space, in the part of the atmosphere known as the mesosphere. These are special clouds: ordinary clouds form at altitudes of no more than 13 km.

In 1883, the Indonesian volcano Krakatoa started to erupt, and in the following years, noctilucent clouds were often observed above cities such as London. According to scientists, they were the result of billions of tonnes of dust and chemicals spewed into the atmosphere by the volcano.

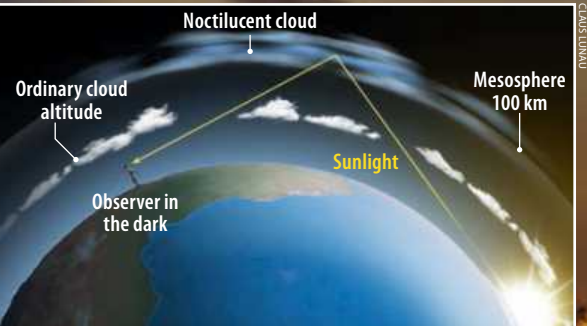
But after the other consequences of the eruption had eased off, the clouds remained, and since then, they have

spread further. In 2007, the US launched a satellite to take a closer look at the phenomenon, and scientists now think that the noctilucent clouds consist of microscopic ice crystals growing on dust particles left in the mesosphere by meteors.

The clouds probably appeared in the late 1800s, as they are related to methane, of which more and more was emitted into the atmosphere as the industrial revolution progressed.

SUN SHINES ON HIGH-ALTITUDE CLOUDS

Although the Sun has set, and darkness has fallen, the night clouds light up. That is because they are located at such a high altitude that the sunlight can still fall on them.



CLAUS LUNAU

WHY DO WE MAKE TOASTS?

The custom of making a toast dates back to Ancient Greece, when the participants of drinking binges greeted the gods. In the Nordic countries, toasting ceremonies were an integral part of pagan parties celebrating the gods. All cultures have their own toasts. In many Western countries, people cannot drink until the host has raised his glass and made a welcoming toast.

IMAGESELECT



IN SHORT

HORNS AND ANTLERS – WHAT IS THE DIFFERENCE?

Consisting of bone and keratin, horns form a permanent part of the skulls of cows, sheep, etc. Antlers consist of connective tissue and are seasonal. Male deer antlers grow in the mating season, only to be shed immediately afterwards.



Noctilucent clouds are located at an altitude of 83 km and consist of meteor dust, methane, and water vapour.

SHUTTERSTOCK



TOP 5 WHICH ANIMAL HAS THE MOST POWERFUL VENOM?

1. Poison frog (*Dendrobates* spp.)

Where: Central and South America

Lethal venom dose: 0.14 mg

2. Inland taipan (snake, *Oxyuranus microlepidotus*)

Where: Australia

Lethal venom dose: 1.8 mg

3. Cone snail (*Conus* spp.)

Where: Tropical oceans

Lethal venom dose: 3.5 mg

4. Brazilian wandering spider (*Phoneutria* spp.)

Where: Brazil

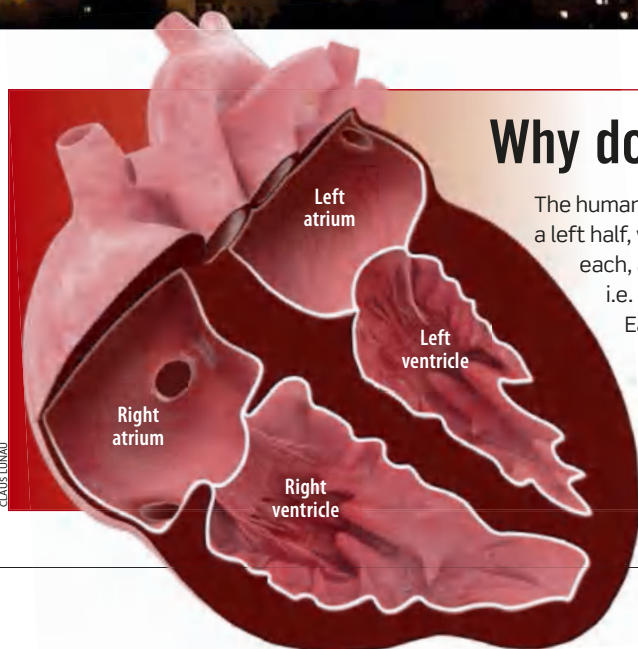
Lethal venom dose: 9.4 mg

5. Puffer fish (*Tetraodontidae*)

Where: Tropical oceans

Lethal venom dose: 25 mg

* Amount of venom required to kill an adult man of 70 kg.



Why does a heart have four chambers?

The human heart consists of a right and a left half, which have two chambers each, an atrium and a ventricle – i.e. a total of four chambers.

Each half makes up a pump.

The two chambers of the right half pump blood to the lungs and back to the heart, whereas the two chambers of the left half

pump oxidised blood to the rest of the body. In each half, blood first flows into the atrium, which contracts, pumping the blood into the ventricle, which immediately pumps it on. The atriums make sure that blood constantly flows into the heart, as the ventricles are blocked by heart valves, when they contract, ensuring that the pumping effect becomes as powerful as possible.

Why do some people walk in their sleep?

Why do some people walk in their sleep, while others do not?

Approximately 5 % of the population walk in their sleep, when they are kids, but for most people, the nightly activity stops, when they have grown up. Sleepwalkers get out of bed when they are in deep, dreamless sleep. Being asleep and unconscious, they may walk about for several minutes, talking. Sometimes sleepwalkers even carry out

sophisticated activities, such as rearranging the furniture, getting dressed, and cooking food, and in 2005, a British girl even ventured onto a crane. In most cases, sleepwalkers return to bed and go on sleeping. When they wake up in the morning, they usually do not remember the episode.

In adults, the phenomenon is often observed during periods of severe lack of sleep. One of the best ways to prevent sleepwalking is to sleep well and for a

long time. Some scientists associate sleepwalking in children with late development of the central nervous system, whereas in adults, it is associated with mental disorders such as schizophrenia and anxiety.

Some studies indicate that migraine victims walk in their sleep more often than other people do, but they are individual studies, which do not provide a clear picture, so scientists do not really know how to explain the causes of sleepwalking.

When people walk in their sleep, it is usually due to lack of sleep or mental disorders such as anxiety.

SLEEPWALKING IS NOT DANGEROUS

Although sleepwalkers have fallen down stairs or out of windows, there is normally nothing alarming about sleepwalking, according to scientists. The condition need not be treated, if only the nocturnal activities take place in a safe manner.

WHAT IS OCTANE?

Octane is a molecule consisting of hydrocarbons, which makes up the main constituent of petrol. The chemical formula of octane is C_8H_{18} . The octane number indicates the fuel's ability to prevent the mixture of petrol and air in engine cylinders from self-igniting, known as knocking, which wears the engine and reduces fuel efficiency. The higher the octane number of the petrol, the more knocking-resistant it is.

IN SHORT

HOW DO PLANETS GET THEIR NAMES?

The planets of the Solar System are named after Greek and Roman mythology. Today, the International Astronomical Union (IAU) names new heavenly bodies – usually after the telescope which discovered them.



Which meteor crater is the largest?

Scientists have discovered the world's largest meteor crater in Australia. During the impact, some of the rock was converted into glass in an area with a diameter of

→ **400 kilometres**

CAN COSMIC RADIATION BE USED AS AN ENERGY SOURCE?

When it is possible to harvest light energy using solar cells, should we not also harvest the energy of cosmic radiation?

Cosmic radiation are particles from outer space, which originate from the Sun, supernovas, and other places. As the particles hit atoms in the atmosphere, showers of other particles arise, of which quite a lot reach Earth's surface.

A few of the small particles from space can

include as much kinetic energy as a baseball travelling at a speed of 100 km/h, but particles with such high energy levels are very rare.

The majority of the cosmic radiation is not very high-energy. The combined energy of the amount of cosmic radiation hitting 12 km² of Earth can only barely make a 60W bulb light up. So, harvesting the radiation is not worthwhile – particularly not considering the fact that sunlight contains almost 300 million times more energy.

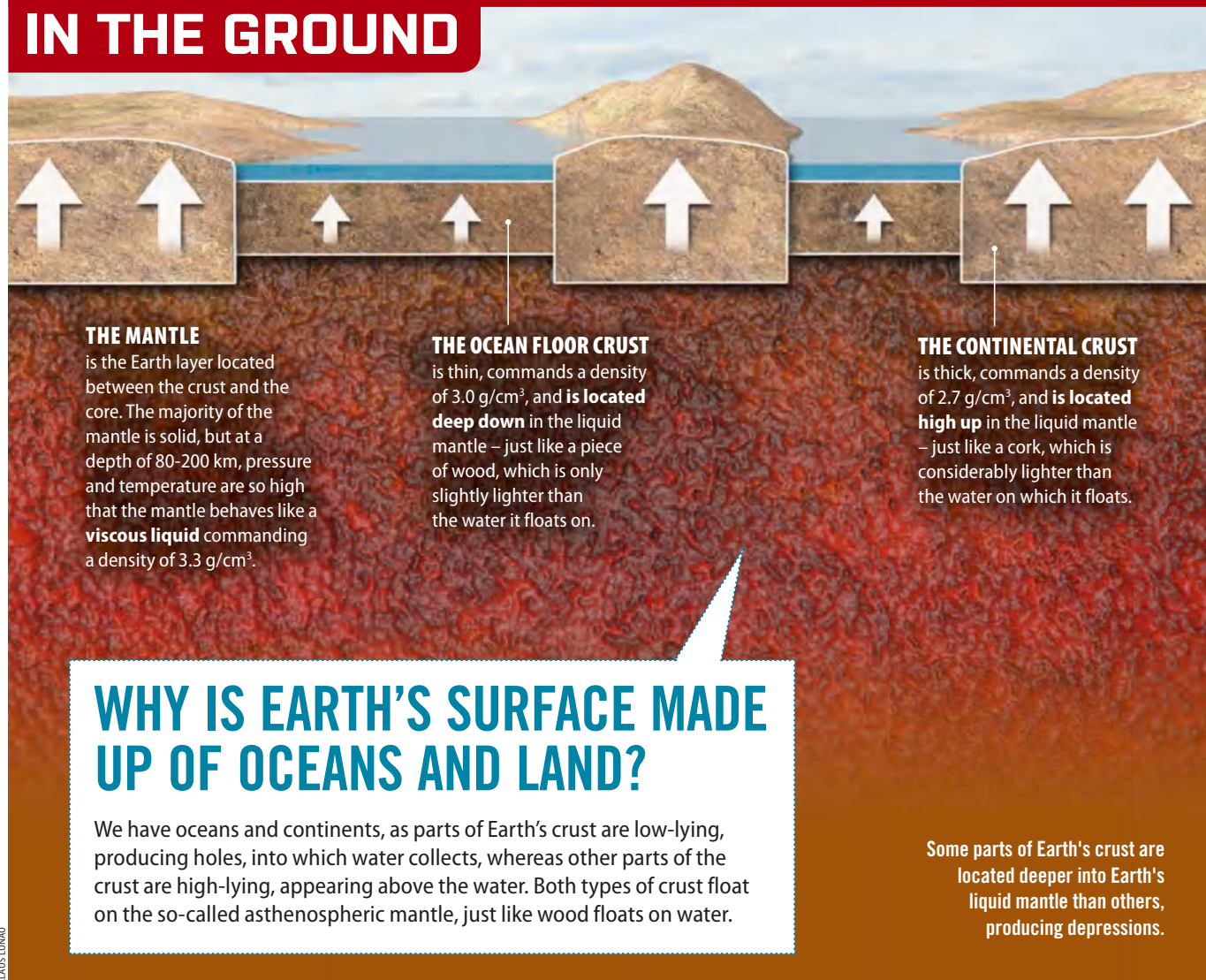
	SUNLIGHT	COSMIC RADIATION
INTENSITY	1,360,000,000 W/km ²	5 W/km ²



The showers of cosmic radiation do not by far contain as much energy as sunlight.

SPRISMANIX

IN THE GROUND



THE MANTLE

is the Earth layer located between the crust and the core. The majority of the mantle is solid, but at a depth of 80-200 km, pressure and temperature are so high that the mantle behaves like a **viscous liquid** commanding a density of 3.3 g/cm³.

THE OCEAN FLOOR CRUST

is thin, commands a density of 3.0 g/cm³, and **is located deep down** in the liquid mantle – just like a piece of wood, which is only slightly lighter than the water it floats on.

THE CONTINENTAL CRUST

is thick, commands a density of 2.7 g/cm³, and **is located high up** in the liquid mantle – just like a cork, which is considerably lighter than the water on which it floats.

WHY IS EARTH'S SURFACE MADE UP OF OCEANS AND LAND?

We have oceans and continents, as parts of Earth's crust are low-lying, producing holes, into which water collects, whereas other parts of the crust are high-lying, appearing above the water. Both types of crust float on the so-called asthenospheric mantle, just like wood floats on water.

Some parts of Earth's crust are located deeper into Earth's liquid mantle than others, producing depressions.

CLAUS LUNAU

HOW DO SEAGULLS FIND PADDOCKS?

I live far away from the sea and have often wondered how 100 seagulls can find a field only 10 minutes after a tractor started to plough it. How do they do it?

Seagulls do not only live near the coast. During the past 100 years, they have learned to live further away from the water. When a tractor is heading into a field, the gulls have learned that it will make lots of small creatures and worms come out.

The reason why gulls relatively quickly collect around a ploughing

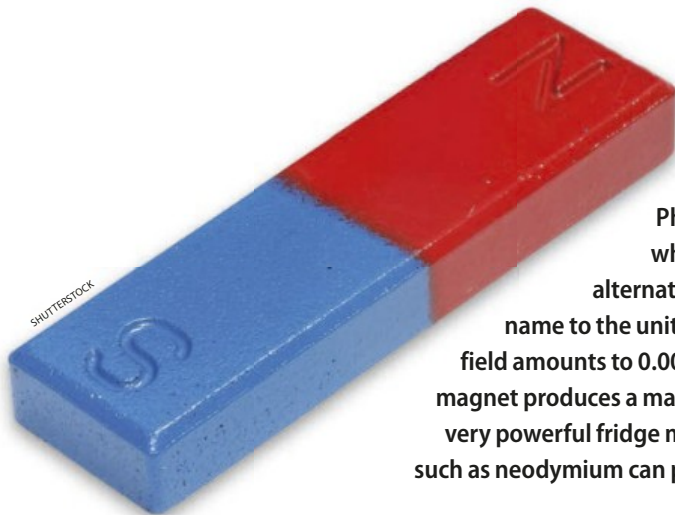
tractor is that they can see and hear each other across long distances, letting out loud calls, which can be heard far away. Gulls help each other look for food like they did back when they were coastal birds.

Near the coasts, the calls can make the gulls collect around a shoal of fish, so they can help each other catch the fish. When a screaming flock of seagulls is beginning to form, it has a magnetic effect on an increasing number of individuals, as they consider the group to be a sign of food.

1. A seagull searching for food spots a tractor heading into a field.

2. The gull calls out, and its call can be heard by other gulls located far away.

3. The prospect of food makes the gulls sound excited, attracting even more gulls.



WHAT IS THE UNIT OF MAGNETISM?

Physicist Nikola Tesla (1856-1943), who made great discoveries via his alternating current research, has lent his name to the unit of magnetism. Earth's magnetic field amounts to 0.00003 tesla (T). An ordinary fridge magnet produces a magnetic field of 0.005 T, whereas a very powerful fridge magnet made of rare types of soil such as neodymium can produce a magnetic field of 1.5 T.

IN SHORT

WHY DOES OLD MILK CLOT?

Milk becomes too old to drink, when bacteria start to digest the lactose, producing lactic acid. In fresh milk, the milk proteins can move about freely, but in the more acid environment, they attract each other into clots.

■ How warm can the human body get?

The highest body temperature ever measured is 45 degrees. The patient was a person under the influence of drugs.

SPECIAL EFFECTS

If a submarine gives in to water pressure, it is doomed, as it has imploded.



IMAGESLECT AUS MANY

Harrison Ford and Liam Neeson play Russian submarine captains in the film K-11: The Widowmaker.

Can a sub be dented without imploding?

In the film "K-11: The Widowmaker", the captain tries to make his submarine dive deeper than the maximum. The hull is badly dented due to the high pressure. But if a sub cannot resist the pressure, will it not spontaneously implode?

The K-11 was a double-hulled Soviet submarine. The dents in the film are probably meant to show that the

external hull will give in, before the entire hull is crushed by the pressure of the water, also known as implosion. The problem with the assumption is that the sub has a cavity filled with water between the two hulls. The pressure in there is the same as in the surrounding ocean, so the external hull will not give in before the internal hull. If the pressure hull gives in, it will be due to implosion.

At a depth of 800 m, the water pressure is approximately 75 atmospheres.

1. The internal hull, also known as the pressure hull, is sturdy, as it must ensure a pressure of one atmosphere for the crew and resist the high pressure from the water.

2. Ballast tanks in the cavity between the 2 hulls are filled with water, when the submarine dives. The pressure is the same as in the surrounding ocean.

Internal hull

External hull

Ballast tank

3. The external hull protects the pressure hull in case of a collision at the surface. It is not pressure-retaining, so if the external hull gives in to external water pressure, the pressure hull has already given in.

IMPLOSION HAPPENS INSTANTANEOUSLY

In 1963, the US nuclear-powered submarine USS Thresher (SNN-593) sank, killing the crew of 129 men. According to studies by US experts, the sub's hull collapsed at a depth of over 730 m. Sound recording analyses indicate that the implosion – and so the total destruction of the sub – happened in about 100 milliseconds.

IS OUR UNIVERSE FULL OF ROGUE PLANETS?

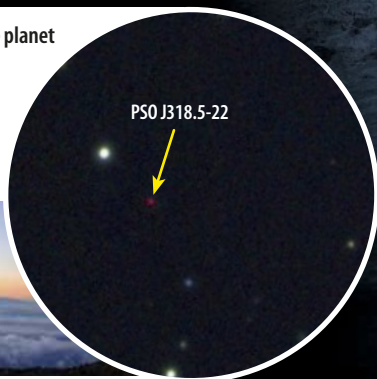
Billions of lonely, rogue planets wander the Milky Way. They have been ejected by their stars and must now exist without their light or heat. And yet, new calculations suggest that these planets could still support an ocean of life...

By Henrik Bendix

80 light years away, the planet PSO J318.5-22 drifts through space alone. It appears here as a **weak red dot** in an image taken by the Pan-STARRS 1 telescope.



UNIVERSITY OF HAWAII



Billions of planets have been ejected by their stars and are speeding through the universe all by themselves.

SHUTTERSTOCK

In a well-organized universe, planets orbit stars, just like Earth orbits the Sun. Some planets are large, others are small, but they are all orbit a star. However, the universe keeps surprising us, and it turns out that planets do not always follow the rules. Some of them have "run away" from their star, speeding through the universe all on their own. Much to the astonishment of scientists, our own galaxy, the Milky Way, contains billions of these rogue planets.

EINSTEIN REVEALS THE PLANETS

An international team of astronomers aimed a telescope at the centre of the Milky Way, and via a computer system, they monitored 50 million stars. The astronomers did not focus on the stars themselves, but on their light.

According to Einstein's general theory of relativity, the light from a remote star

can be bent and even amplified by a massive object such as a planet passing in front of the star. Suddenly, it looks as if the star is shining more brightly. Known as the gravitational microlensing effect, the phenomenon is used by astronomers to search for the rogue planets.

A planet the size of our Solar System's largest, Jupiter, amplifies the light from a remote star for less than two days, so the scientists focused on these brief events. Having double-checked with colleagues in Chile, the astronomers could confirm a total of seven cases of starlight briefly being amplified by rogue planets.

Though seven planets doesn't sound like a lot, it was more than enough to enable the astronomers to start calculating how many of these Jupiter-like, rogue planets exist in the Milky Way. Surprisingly, our galaxy contains almost twice as many rogue planets as stars – in the order of hundreds of billions.

SLIGHT HEAT RADIATION EMITTED

At night, when we can see the other planets of the Solar System, it is so, because they reflect the light of the Sun, but planets without stars cannot shine as brightly. Still, it is not impossible to take a closer look at them, as they emit a little heat, and the heat radiation can be detected by special telescopes.

Although the rogue planets do not receive heat from a star, they are not completely cold. They slowly emit heat in the form of thermal infrared radiation. When a planet is formed, pressure and temperature in its interior rise, and radioactivity can also heat the planet.

By studying images taken by the Pan-STARRS 1 telescope, located in Hawaii, astronomers have discovered a planet, which has been named PSO J318.5-22. The planet is rogue, and located about 80 light years from us. It emits extremely weak ▶

Starlight reveals planets

Massive objects can function as a type of lens, which will briefly pick up the light from a remote star. The so-called **gravitational microlensing effect** is used in the search for planets which do not orbit a star.

The infrared WISE telescope searches for rogue planets.

1

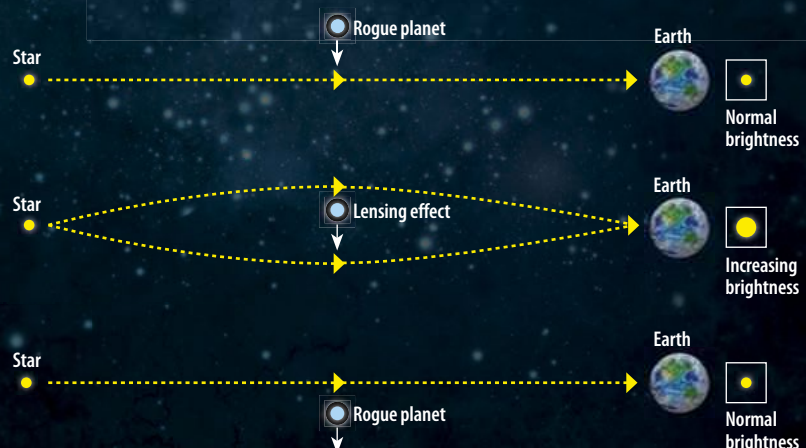
The light from remote stars is **captured by telescopes**. Astronomers observe whether the brightness is constant or not.

2

A planet passes in front of the star, and the **light is bent** around the planet. When light comes from several directions, brightness increases.

3

It typically takes **a few days** for a large planet to pass in front of the star. Afterwards, the brightness goes back to normal.





Earth is not in danger of collision

The Milky Way is full of rogue planets, but we need not worry about one of them suddenly colliding with Earth, because while the Milky Way contains billions of these objects, there is also lots of space. That said, the closest rogue planet is probably closer to Earth than the closest star, Proxima Centauri. But that star is located approximately **42,000 billion km** away from us. The distances of the universe are simply so immense that the risk of a collision with a wandering planet is extremely small.

It is much more likely that a rogue planet will be adopted by a new star. On its way through space, the planet may be captured by the gravity of a star and begin to orbit the star. The theory can explain why mysterious planets have been observed in orbits unusually far away from their stars.

The distances within the Milky Way are so immense that a collision with a rogue planet is almost impossible.

CREATIVE COMMONS

► infrared light. It can only be observed, because its mass is 6.5 times Jupiter's, making this planet an absolute heavyweight.

PLANETS THROWN FROM THE NEST

Where these billions of rogue worlds come from remains a mystery, but astronomers have several theories. According to one, the planets formed alone from a cloud of dust and gas in the same way as stars originate. According to another theory, they form like the Solar System's planets, - from a disc of matter surrounding a young star. But at some point in their evolution, they were ejected from their stellar system - like when a baby bird is thrust out of the nest by its bigger siblings.

Scientists tend to support this theory, and quite a few astrophysicists are even convinced that our solar system contained more planets in its youth, four billion years ago. In the beginning, the Solar System was probably a very unstable and chaotic place,

2018

is the year in which the James Webb telescope will intensify its search for rogue planets.

in which the planets had not yet found their present-day orbits.

According to a well-established model of our Solar System's development, the gas giants Jupiter and Saturn first moved towards the Sun, only to lose momentum and drift out to their present orbits. En route, they interrupted the orbits of other planets, and computer simulations carried out by American astrophysicist David Nesvorný show that a planet the size of Uranus or Neptune may have been ejected from the Solar System due to Jupiter's gravity.

Other models indicate that smaller

planets the size of Mars were also ejected from the Solar System in connection with Jupiter's and Saturn's migration.

So, one or more planets that formed in the young Solar System and were later ejected could now be drifting through space on their own. Other stellar systems may also have lost planets in the turbulent past, and so, the number of rogue planets could indeed be as high as indicated by the astronomical estimations.

LIFE MAY ORIGINATE FAR FROM A STAR

The rogue planets live cold, dark lives without any connection to a star, but astronomers still think that they could still support some form of life.

On Earth, the vast majority of all organisms depend on energy from the Sun, but some microorganisms can survive without sunlight, as they have found another energy source. That is true for microbes thriving in the darkness of the deep oceans

How about a rogue Galaxy?

Not only planets, but also entire galaxies can be rejected. Two Russian astronomers discovered that in 2014, when they decided to search for a particularly rare type of galaxy.

Even huge systems such as galaxies can go rogue. In 2014, Russian astronomers discovered 195 rare compact elliptical galaxies, which have lost most of their stars, so only the innermost ones remain. Eleven of these are located far away from the galaxy clusters in which galaxies are normally to be found.

According to scientists, the compact galaxies were once large, but they collided with even bigger galaxies that swallowed their outermost stars. Subsequently, a third large galaxy passed by, and as the two big galaxies interacted, the compact elliptical galaxy was accelerated away, to wander through space.

close to hydrothermal vents, where warm, nutrient-rich water flows out of cracks in the ocean floor.

Similarly, rogue planets could support life, as long as their interiors produce enough geothermal heat to keep water liquid. According to the calculations of two American scientists, a planet that is at least 3.5 times heavier than Earth could still have an ocean under its ice sheet. The heat from the interior of the planet can keep the water liquid, but only if the ocean is covered by ice, which can function as an insulating blanket.

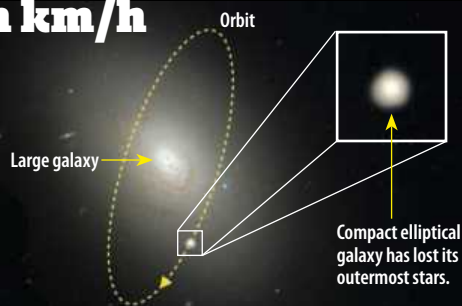
Smaller planets could also have such an ocean, but only if they hold much more water than Earth or used to have a thick carbon dioxide atmosphere, which has subsequently frozen and come to cover the surface like an extra blanket.

HUBBLE REPLACEMENT COULD SOLVE MYSTERY

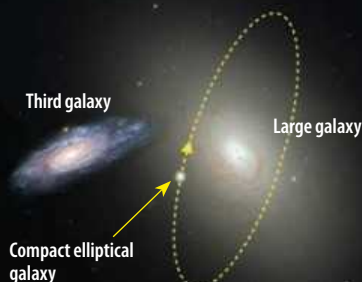
We will get an idea of whether the scientists' theories hold water, when new, improved telescopes are put into service in the years to come. The James Webb telescope replaces Hubble in 2018, and it will be able to take more and sharper images of the rogue planets. Also, astronomers expect a lot from the future Wide-Field Infrared Survey Telescope, which can use the microlensing effect to search for wandering worlds. According to the mission schedule, the new telescope will be launched in 2024. 

Miniature galaxy ejected at 10 million km/h

1 Two galaxies orbit one another. The larger one has swallowed the outermost stars of the smaller one, which has become a compact elliptical galaxy.



2 A third galaxy gets in the way, before the large galaxy and the compact elliptical galaxy become one.



3 Under the effect of the gravity of the two large galaxies, the small, compact galaxy is ejected at a speed as high as 10 million km/h.



The TEXUS 51 research rocket is launched from the hostile Arctic landscape surrounding the Esrange Rocket Range.



ARCTIC AEROSPACE

Europe's biggest rocket range, the Esrange Space Centre, is located among reindeer and vast, snow-covered expanses near the Swedish mining city of Kiruna. Starting in 2020, humans and satellites will be launched into space from the Arctic wilderness.

By Gunver Lystbæk Vestergård. Photos: Jesper Rais

Europe's new spaceport is in Sweden

- **SPACE RESEARCH**

The solar wind at Mercury

- **ROCKET LAUNCH**

Research missions to space

- **SPACE TOURISM**

100,000 visits to the site a year



Space university specialises in solar weather

Some of the world's leading solar wind experts are working at the Swedish Institute of Space Physics (IRF) in Kiruna. Right now, the space university's instruments are orbiting Venus, Mars, Saturn, and more – just like the IRF is monitoring solar particles in Earth's atmosphere.

Solar wind consists of charged particles emitted by the Sun, which create auroras, and other effects in the atmosphere, or disrupt satellite communication. Every

object orbiting the sun is subject to solar wind. Outside Kiruna, there is a satellite dish with a 32 m diameter, which uses radar to monitor electron clouds produced by solar wind in our atmosphere. The dish is a part of a Scandinavian radar network known as EISCAT. The radars can see space junk down to 20 mm and up to 1,500 km away. The IRF contributes small

weather stations and particle detectors to ESA and NASA missions such as to the BepiColombo, Europe's first mission to Mercury (due to launch in 2017).

The instruments can measure magnetic fields and capture ions from solar wind.



The Swedish Institute of Space Physics builds instruments, that are going to orbit Mercury.



ESA tests the BepiColombo craft, which is to orbit Mercury.

ANNEKE LE FLOCH/ESA

At the Esrange Space Centre, 40 km outside Sweden's northernmost city of Kiruna, two biomedical scientists are working with a cell microscope. With intense concentration, they are trying to focus on just one of the 100,000 cancer cells on the small plastic disc: a huge task, when the cells and the microscope are actually located 260 km into space, having travelled there at a speed of 7,200 km/h.

Sascha Kopp of Germany and Thomas Corydon of Denmark are rehearsing, while the world's first space microscope that can

photograph cells in a state of weightlessness is still on the ground. The cylinder-shaped microscope will eventually be placed in a shining, rose-coloured TEXUS "sounding rocket" and launched to the edge of space.

Kiruna is already home to a space university, a space high school, and the world's biggest civil satellite receiver station, and Esrange is Europe's leading rocket range. But the Swedish ambitions reach beyond research rockets launched from the Arctic landscape, where reindeer and dog sledges must share the few roads, and auroras light

the night sky. Sweden has initiated the vision of Space Kiruna, which is going to launch people and satellites into space from Europe.

TRIAL AND ERROR

Sascha Kopp keeps on turning the knob to adjust the focus of the cell microscope during the rehearsal. Two deep worried lines appear on Thomas Corydon's forehead. Only greyish black blots can be seen on the computer screen. They are struggling, and the six simulated minutes of weightlessness are coming to an end. But with seconds to ►



Esrange's satellite dishes are scattered across the Arctic landscape.

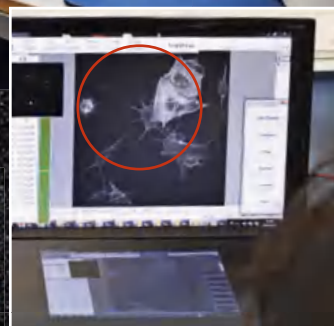
Scientists are testing the microscope, which will register how cells react in a weightless environment.

The tiniest astronauts light up

In order to find out how the human body will react to long space missions, scientists are sending different cell types into space.

On the TEXUS 52 mission in April 2015, cancer, immune, and brain cells were tested in zero-g (or more correctly, free-fall). Space medicine experts discovered that human cells perform poorly in this state, which affects the immune system, brain, heart, and muscles. The key to understanding the bizarre cell behaviour in space may be found in cells' internal scaffolding, the cytoskeleton, which supports a cell

like the pegs of a tent. The cytoskeleton collapses in free-fall, sending a signal to the protein factory, the ribosome, that something has changed. This makes the ribosome produce different types of proteins than it does on Earth; proteins that scientists can study. If humans are to go on space missions of several years, scientists need to learn more about the behaviour of those cells.



When the cells are viewed through a microscope, their internal structure can clearly be seen.

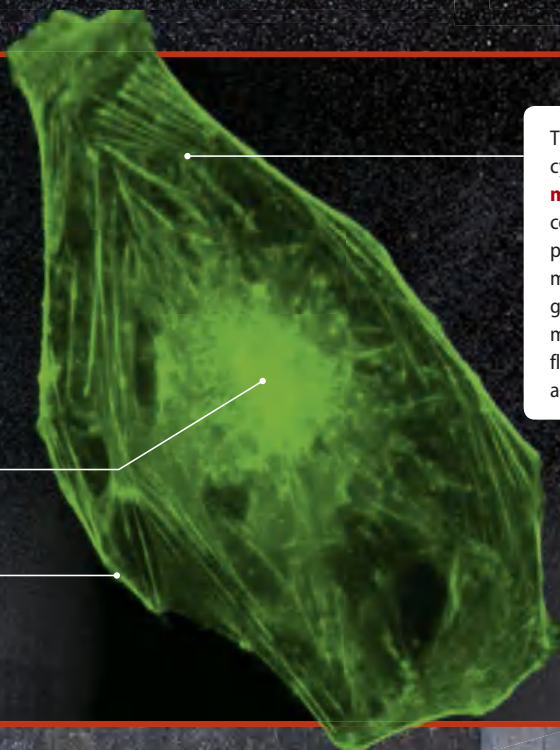
CELL SCAFFOLDING STUDIED IN SPACE

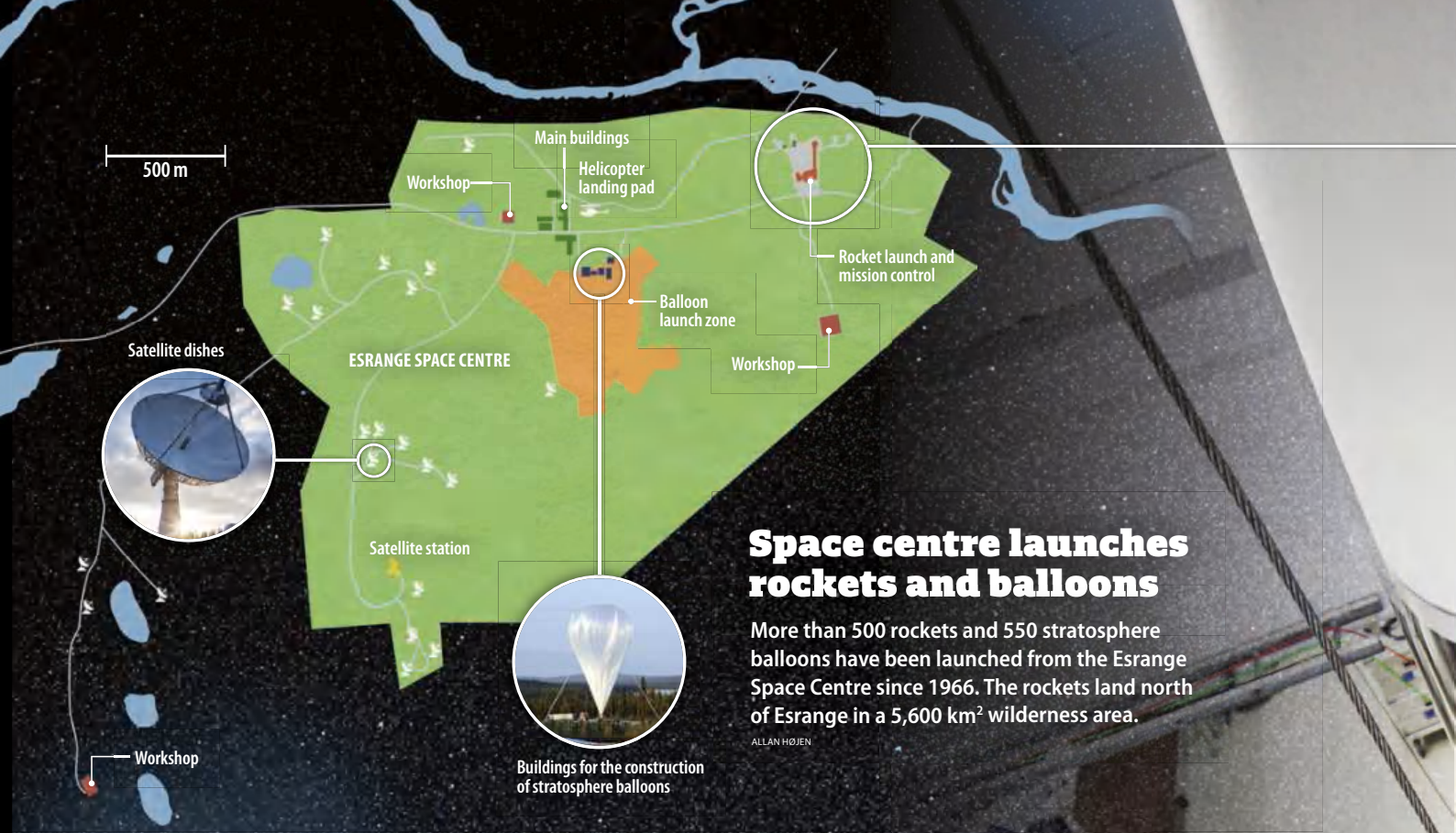
Scientists are studying the cells' internal scaffold, the cytoskeleton, to understand cell behaviour in space. The cytoskeleton consists of a number of "tent poles" that behave in a special way in zero-g.

At the centre of the cell, you can see the **nucleus**, which is locked in a network of microfilaments.

All cells are lined with cell membranes. The **cytoskeleton** attaches to the membrane like tent poles to tent canvas. At zero-g, the pegs relax, as they are not affected by external pressure.

The thin poles of the cytoskeleton are called **microfilaments**. They consist of chains of actin proteins. The cell is just 40 micrometres wide and genetically modified to make the microfilaments fluoresce green under a microscope.





Space centre launches rockets and balloons

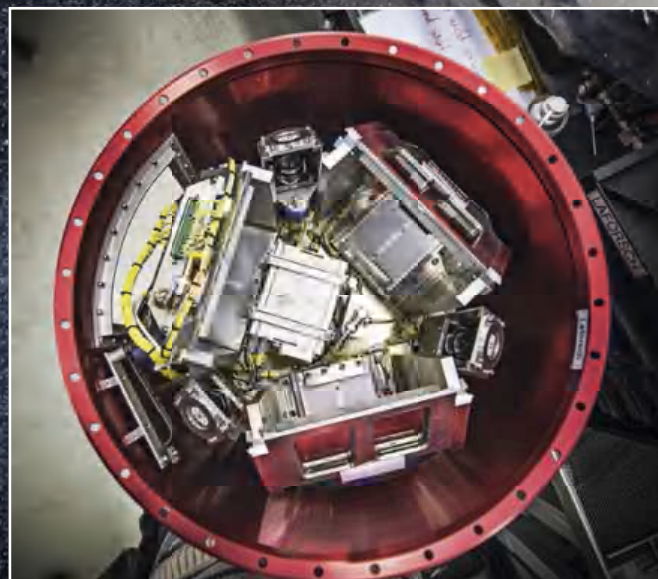
More than 500 rockets and 550 stratosphere balloons have been launched from the Esrange Space Centre since 1966. The rockets land north of Esrange in a 5,600 km² wilderness area.

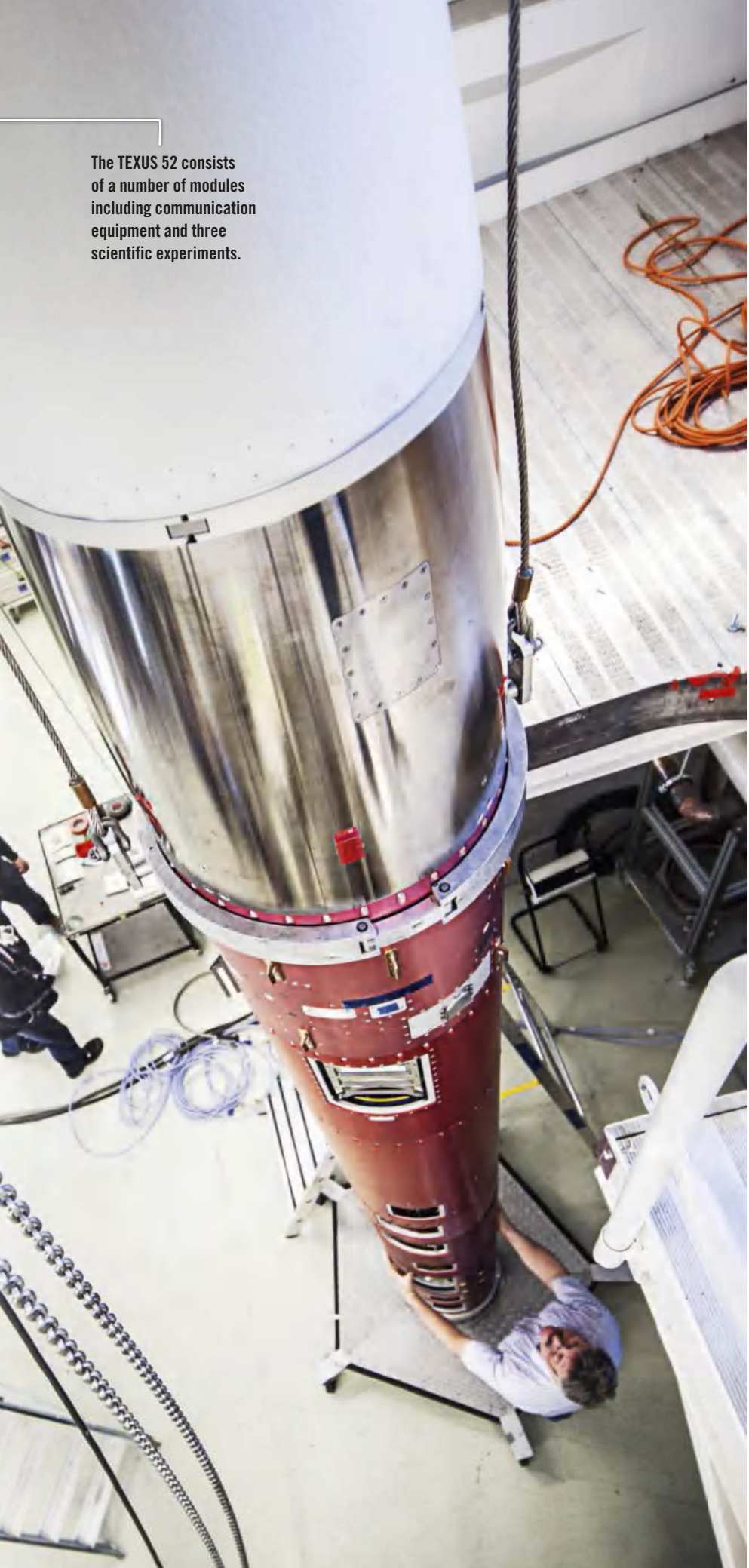
ALLAN HOJEN



◀ Airbus engineers are assembling the TEXUS 52 rocket, mounting the parachute module on top of the control system module.

▼ This experiment will study predators' behaviour in free-fall. The containers hold tadpoles and daphnia.





The TEXUS 52 consists of a number of modules including communication equipment and three scientific experiments.

► spare, Sascha Kopp manages to focus on a cell and produce a delicate green cobweb on the screen. The rehearsal reveals weaknesses in the design of their experiment. The two scientists will pre-focus the microscope on three cells before launch. If the microscope and the cells do not move during the rocket launch, the scientists can concentrate on taking good pictures during the minutes of weightlessness, before the rocket falls back to Earth.

During the rehearsal, the cells moved 60 micrometres, and as the microscope can only be moved 300 nanometres at a time, the scientists must turn the manual dial 200 times to find the cell again, which is almost impossible. The \$5 million experiment seems headed for failure.

The TEXUS rocket with the cell experiment is the 52nd TEXUS research launch. At the cone-shaped launch tower a few hundred metres from the workshop, the 13-m-tall TEXUS 51 is dormant. It has been ready for about a week, but high winds delay the launch. The TEXUS rockets, which have been paid for by the German space agency DLR and built by German and Brazilian engineers, cannot be allowed to drift south into inhabited areas. North of the range, an area slightly larger than Luxembourg is deserted apart from a few flocks of reindeer which makes it perfect for rocket impacts.

FROM CLOUDS IN SPACE TO CELLS

The first sounding rockets did not focus on weightlessness, they studied the clouds of charged particles that collect in the top part of the atmosphere, the ionosphere, when it is affected by solar wind.

Ionospheric research set off the space age in Kiruna with the establishment of the Swedish Institute of Space Physics (IRF) in 1957. Today, exhibition cases in the corridors show that many of the sounding rockets, which have studied the solar wind, included IRF instruments. Today, the IRF is also the headquarters of the development of one of the world's most sophisticated radar systems for mapping out the ionosphere: EISCAT_3D. The system is going to consist of five fields throughout Scandinavia, each made up of approximately 30,000 small antennas. One of the test areas is located at the Esrange Space Centre, which was built in 1964. In the early days, the space centre was owned by the European Space Research Organisation (ESRO, the future ESA), but later, it was ►

Tried and Tested

The TEXUS rocket is the world's oldest active suborbital research rocket and has lifted experiments into space since 1977. The latest (at time of writing), the TEXUS rocket No. 52, was launched from the Esrange Space Centre in April 2015.

6 THE ROCKET NOSE
is made of metal, but covered by a plastic layer to protect it against the heat. **The plastic layer melts** and evaporates during launch, when friction causes temperature to rise to 300 degrees.

5 THE PARACHUTE
is made of thin, synthetic cloth and boasts a 20 m diameter. It **automatically unfolds** 4-5 km above the ground.

4 A BALANCING RING
harmonises load weight differences, keeping the rocket steady. The balancing ring is a bowl-shaped cavity, in which weights are placed.

3 A GPS ANTENNA
is located close to the nose, constantly transmitting data to mission control concerning the location of the rocket. A few seconds after launch, the GPS can also calculate **where the rocket will land**. Engineers cannot control the rocket, but are in constant contact with it, receiving data and images from the ongoing experiments.

2 THE SECOND MOTOR
takes over from the first. About one minute after lift-off, the second motor burns out at an altitude of 43 km and is disconnected. The rocket continues to **an altitude of 260 km**, before succumbing to gravity and falling back to Earth.

1 THE FIRST MOTOR
The fuel consists of aluminium powder mixed with an oxidizing agent. An electric spark ignites a capsule with black powder. In a matter of milliseconds, the entire rocket motor has been ignited, and the force of the huge, controlled **explosion lifts the rocket**. The motor burns out and is disconnected after 14 seconds.

ALLAN HØJEN

EXPERIMENT 1

Weightless cells are filmed

Cancer, immune, and brain cells are filmed live through a microscope to learn how their interior structures change in free-fall.



EXPERIMENT 2

Future displays are studied

Liquid crystals can flow like liquids but maintain crystalline structures. On Earth, the crystals collapse, but in zero-g, they can grow taller. The crystals are used in LCD displays, and by building figures in free-fall, scientists hope that the crystals will reveal new characteristics.



EXPERIMENT 3

Predator instinct tested in space

In this experiment, predators (tadpoles) are allowed to attack daphnia "water fleas" to see how prey and predators interact in free-fall.



66

Esrange will now focus on the growing micro-satellite market.

► taken over by the Swedish Space Corporation (SCC), which is the national Swedish agency. Some 550 sounding rockets and a similar number of stratosphere balloons have been launched from the range since then. The rocket experiments typically involve the testing of equipment that is to be installed on satellites or sent to the International Space Station (ISS). Scientists also test semiconductors and liquid crystals, which reveal unknown characteristics in a state of weightlessness.

A growing share of the experiments are biological or medical such as Corydon's and Kopps' microscope project. Scientists used to believe that microscopic life such as bacteria and human cells do not change in zero-g, but they were wrong. The cells change dramatically, which Corydon's and Kopp's space microscope will contribute to proving.

NO BADGE, NO LAUNCH

On 23 April, a launch window finally opens, as the wind decreases in intensity. The TEXUS 51 rocket must be woken up. Four hours before the launch at 8 o'clock, the countdown begins. One hour before lift-off, cables and hoses are disconnected, and the rocket's electric ignition is readied. All mobile phones are turned off, as electromagnetic signals could ignite the rocket.

Thirty minutes before launch, the countdown stops. The wind is still a problem, so two weather balloons are launched. The security staff makes sure that nobody is close to the rocket. Anyone going near it on the day of the launch get a badge which must be given back no later than 20 minutes before launch. But badge No. 9 is missing. Phone calls are made to locate it.

The missing badge may prevent the

Dice to be rolled in space

Once, satellites were the size of buses, but today, the smaller ones fit into a backpack. A type of microsatellite known as CubeSat is gaining ground fast at the moment. Just 10cm on a side, they can be combined into larger units. The price of launching a traditional satellite can top \$200 million, but a CubeSat can be launched for as little as \$20,000, appealing to companies and universities.

From 2020, the New Esrange will launch CubeSats using VLM rockets. With its 3 motors, the rocket will be able to lift about 150 kg into orbit.



CubeSats weigh about 1 kg each and cost as little as \$8,000.



MONTANA STATE UNIVERSITY/PP - CALTECH/NSA & CREATIVE COMMONS

entire launch, but after a few minutes, it is found, and shortly after, the TEXUS 51 roars off from the launch tower. At an altitude of 100 km, the rocket's speed and acceleration precisely cancel out the pull of gravity from the planet below - it is weightless.

Twenty minutes after lift-off, the payload is back on the ground, where it is picked up by a helicopter. Right now, Esrange only launches "sounding rockets" which cannot attain orbit, and so fall back to Earth. The New Esrange, under construction, will be able to launch small satellites into an orbit around Earth. At

the moment, European rockets are launched from the US, Russia, or French Guyana, but Esrange focuses on the growing micro-satellite market. The small, square CubeSats are becoming more and more popular among companies and scientists.

Esrange already has lots of satellite experience, as the range includes the world's biggest civil satellite receiver station. The hilltops surrounding Esrange are not only forested, they also include huge satellite dishes with diameters of up to 13 m. Since 1978, when the station started out ►



The Esrange Space Centre appears rather small in the vast Arctic wilderness.

According to plan,
Spaceport Sweden will
be Virgin Galactic's
European base.

SPACEPORT SWEDEN

Space Kiruna may launch tourists into space

Virgin Galactic is looking into the possibility of launching space tourists from Northern Sweden.

The minds behind Space Kiruna are a group of tourist organisations, scientific institutions, public bodies, and private companies. Together, they aim to attract 100,000+ tourists annually for aurora-watching, rocket launches, space attractions, and space missions aimed at the lucky and wealthy.

Virgin Galactic, which hopes to be able to launch tourists into space at a price of \$270,000+ soon, has agreed with Spaceport

Weightlessness experiences and tourist space missions will be central Space Kiruna activities.

Sweden to look into the possibility of launching its spacecraft, SpaceShipTwo, from Kiruna. Space Kiruna will also be a space research hotspot, since it will remain the only spaceport for satellite launches in Europe.



SPACEPORT SWEDEN

SPACE KIRUNA WILL BE EUROPE'S LEADING SPACEPORT BY 2020

- Tourism flights to the border of space offered by companies such as Virgin Galactic and XCOR.
- The first satellite launches (not just tracking) from Europe.
- Up to 10 space probe launches and 5 balloon launches annually.
- The world's biggest satellite receiver station in contact with over 60 civil satellites.
- Space high school and university.
- Headquarters of the extensive EISCAT_3D radar project, which is going to take the first 3D images of the atmosphere.
- Large experience centre known as the Space Visitor and Science Centre.

► with one satellite dish and tracking just one satellite, it has grown by approximately one dish per year to 30.

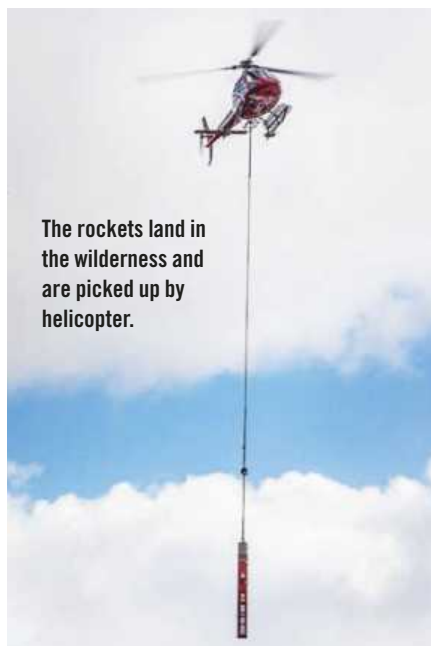
The vast majority of satellites orbit the poles, not the Equator. So, to be in frequent contact with your satellite, you need to be as close to a pole as possible. Esrange is located 200 km north of the Arctic Circle, and collects data from 60 civil satellites.

PLANS FOR A SPACE TERMINAL

The satellite station is manned 24/7, but rocket launches are seasonal, taking place in the spring and autumn. As we write this, the annual spring launch windows are coming to an end, so it is quite urgent to get the TEXUS 52 and the cell microscope launched. The first 24 hours after the launch of the TEXUS 51, the tower is still so full of toxic vapour from the rocket motors, that nobody can enter it. They just have to wait.

When the crew finally gets access to the tower, a hatch sticks. The scientific experiments cannot be linked with the two rocket motors and placed in an upright position. It takes approximately 12 hours for engineers to open the hatch.

Luckily, the weather is still nice, and in the middle of the night between 26 and 27 April,



The rockets land in the wilderness and are picked up by helicopter.

Sascha Kopp can finally enter the bunker, from where the rocket and the microscope are controlled. Anxiety has prevented him from sleeping for the past couple of days, but now, he is calm, ready to adjust the dial. Thomas Corydon and Research Director Daniela Grimm have to wait 1000m away in the cafeteria, from where the launch is

observed. At last, the TEXUS 52 takes off.

The old saying that a bad rehearsal produces a splendid first performance is true. Sascha Kopp manages to take photos even better than he imagined.

"From the end of the world, we are happy to announce that we are flying!" Thomas Corydon cheers.

The biomedical researchers now enter a race against a new clock – the publication clock. The six minutes of weightlessness were shared with two other teams of scientists, who also used the space microscope for experiments involving brain and immune cells. The first team to publish its results gets the most credit. Cell experiments in space are still a very new field, and each experiment is very likely to result in a new discovery.

The same pioneering spirit exists in connection with the part of the Space Kiruna vision concerning space tourism. A growing number of adventurous rich people buy tickets for brief sightseeing trips to the border of space. Spaceport Sweden in Kiruna is negotiating with companies such as Virgin Galactic and XCOR to be the first outside the US to launch space tourists. Spaceport Sweden expects to be ready to send the first humans into space from European soil in 2020. **SCI**



After a mission, the rocket motors are scrapped and left in the rocket cemetery.



NCOMARRE & SHUTTERSTOCK

A radical and dangerous operation will give this paralysed man a **NEW BODY**

During 36 hours of surgery, 100 doctors and nurses will move the head of a severely disabled man to a healthy donor body. According to critics, the spinal nerves will suffer permanent damage, paralysing the patient. But the



Surgeon Sergio Canavero (right) intends to give his disabled patient, Valery Spiridonov (left) a new body to save his life.

lead surgeon will ignore the critics' warnings: The risky surgery will be carried out in 2017, and the patient is keen. Nobody has ever tried anything like this before.

BY MALLINZ/UMA PRESS/CORBIS/ALL OVER

The world's leading neurosurgery experts are listening in disbelief to Italian surgeon Sergio Canavero. The speaker reminds them of Frankenstein, the legendary gothic character, who combines body parts of the dead to create a new human being. And the audience can hardly believe it, when he says: "Watch out! I am the real one!" Beside Sergio Canavero, a man in a motorised wheelchair is looking at the audience. He has been selected to play an important role in this real-world Frankenstein project. In less than two years, he will subject himself to surgery, where if all goes well he will gain something very important: a healthy new body.



VLADIMIR SMIRNOV/TASS/SCANPIX

Valery Spiridonov suffers from a disease that weakens his body's muscles.

A SECOND CHANCE

This patient is a 30-year-old Russian computer expert by the name of Valery Spiridonov. There is nothing wrong with his brain - or indeed his whole head - but his body is crippled. The Russian suffers from a rare, hereditary disease known as Spinal Muscular Atrophy, in which the spinal cord nerve cells, which control muscles throughout the body, start to die off when the patient is just a baby. Patients do not become paralysed, but their muscles weaken, so they can never walk or stand up. The diaphragm and chest muscles eventually weaken so much, the patient suffocates. Spiridonov is dying, and so, he has

decided to take part in the world's first "head transplant" to free himself from his crippled body, and hopefully get a second chance at a normal, healthy life.

THE MONKEY COULD HEAR, EAT, AND SEE

The surgeon's head transplant speech was given at an international medical congress for neurologists and surgeons in the summer of 2015. The plan to cut the head off a living human being and move it to the body of a brain-dead person may seem like science fiction, but back in 1970, American neurosurgeon Robert White transplanted the head of a monkey to the body of another monkey. The ground-breaking experiment was partly successful. The "spliced" monkey could hear, smell, eat, see, and follow an object with its gaze.

But the nerves of the spinal cord had been damaged, so the brain could not move the new body. The monkey was paralysed, and soon, its body began to reject its head. One week later, it died.

SPECIAL SCALPEL PROTECTS NERVES

According to Canavero's critics, the nerves of the patient (like those of the monkey) will not be able to heal properly again after the surgery. They base their opinion on experience from accidents, in which the spinal cord nerves of the victim have been brutally

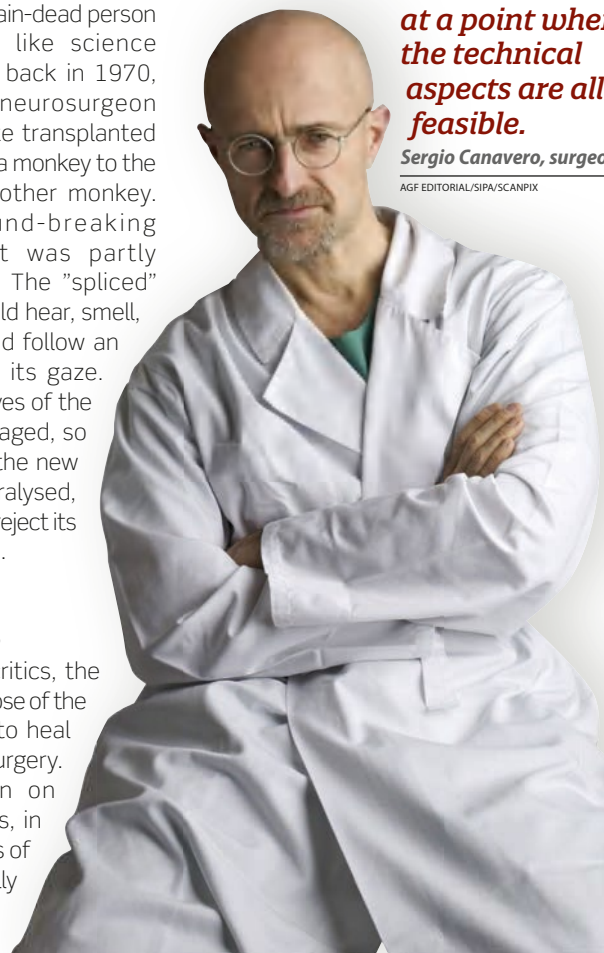
torn apart. Except in very rare cases, the spinal cord won't heal, and the victim will be confined to a bed or a wheelchair for the rest of his life. But Sergio Canavero has figured out that while in an accident, the spinal cord is affected by a force of 26,000 newtons, the surgery will affect it by less than 10 newtons, causing much less damage.

Another important difference is that while an accident will leave the nerve endings ▶

"I think we are now at a point when the technical aspects are all feasible."

Sergio Canavero, surgeon

AGF EDITORIAL/SIPA/SCANPIX



65 YEARS OF TRANSPLANTS

Since the 1950s, surgeons have transplanted the limbs of both animals and humans - often with limited success. But the results of recent years indicate that doctors have improved their skills.

1959

DOG WITH TWO HEADS DIED AFTER A FEW DAYS

In the 1950s, Soviet surgeon Vladimir Demikhov carried out several transplants, by which an extra head or upper part of the body of one dog was moved to another dog. Usually, the animals died a few days after the surgery.



BLINDSARCHIV

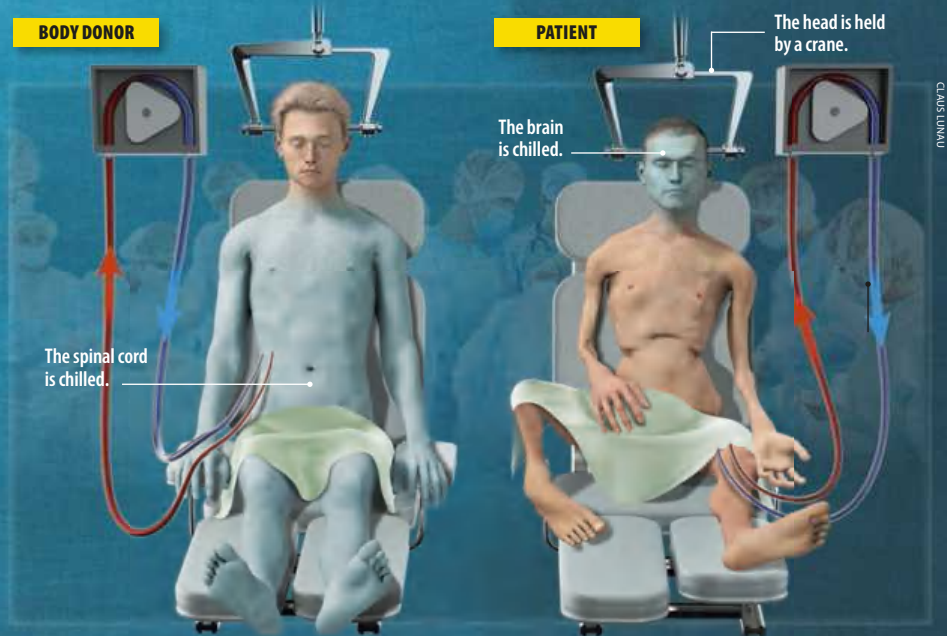
The transplant step by step

The surgeon, Sergio Canavero, has devised an elaborate plan for the transplant procedure. The biggest challenge consists in fusing the nerves of the new body and the head.

1 Head and spinal cord are chilled

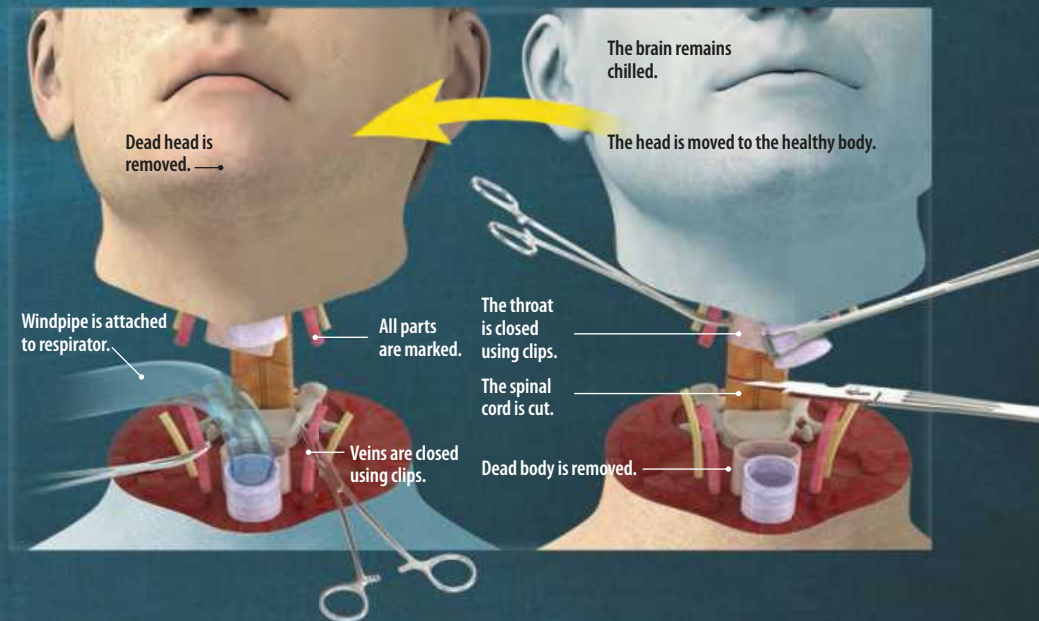
To protect the tissue during surgery, doctors will chill body parts. The procedure protects nerves and tissues which would otherwise die at room temperature without oxygen. The patient's arteries are opened, and the blood is connected to a cooling device that chills the brain to 10 degrees. The body donor's spinal cord is cooled to 10-15 degrees by pumping cold, salty liquids in between the vertebrae.

- Body part to be scrapped
- Body part to be used



2 Head is removed from body

The skin of the neck, muscles, nerves, and other tissue of both donors are cut. Blood vessels and the throat are closed using clips, and all parts are marked, so they can later be correctly "reassembled". Air flows directly into the body's windpipe, which is attached to a respirator. A small saw is used to cut off some of the neck's two vertebrae, exposing the nerve bundle of the spinal cord, and finally, the spinal cord is severed in a perfectly clean, ultra-precise cut.



1970

NEW HEAD PARALYSES MONKEY

American neurosurgeon Robert White transplanted the head of one monkey to another monkey's body. After surgery, the monkey could hear, smell, eat, see, and follow an object with its eyes, but its body was paralysed, as the spinal cord nerves had been damaged. Moreover, the body started to reject the head, and a week later, the monkey died.



2002

HEAD GREW ON RAT THIGHS

Japanese scientists cut the heads of baby rats and transplanted them to the thighs of adult rats to study the blood supply to the brain. The heads grew and moved, and the brain developed for at least 3 weeks.



Human hair:
0.1 mm thick

*The scalpel cutting the central nerves has been sharpened to a thickness of only **0.00001 mm** – 10,000 times thinner than a human hair.*

ARDEA/SCANPIX

► ragged and torn, Canavero will use an ultrasharp scalpel, producing two clean cuts. The doctor intends to make the cut with a diamond cutter, which has been sharpened to a thickness of only 0.00001 mm. So, the scalpel is 1,000 times thinner than a human cell, and it will cut through the tissue of the spinal cord using a very slight pressure. The clean cut improves the possibilities of placing the pairs of nerve endings correctly opposite each other, allowing them to reconnect.

CHILLING BUYS DOCTORS MORE TIME

Time is critical in this surgery. Once patient's head has been cut off, the brain receives no blood, oxygen, or sugar from the body. Under such circumstances, the brain can survive for no more than five minutes without suffering permanent damage, and that is obviously not enough. Even when doctors and nurses work as efficiently as they can, it will take about one hour to reconnect all blood vessels,

the windpipe, and the nerves. So, doctors must find a way to buy more time. Before surgery, the brain of the patient is chilled to a temperature of 10 degrees by cooling the blood flowing to the head. In addition, freezing cold liquids are pumped into the donor's spine, lowering the temperature of the spinal cord to 10-15 degrees. At this temperature,

all biological activity in the delicate nerve tissue is reduced, so the energy and oxygen consumption is very limited. Several scientific experiments and real drowning accidents have shown that cooling works.

One example is a Swedish doctor, Anna Bågenholm, who fell into an ice-covered river on a skiing trip in 1999. Her head was trapped under the ice. In the freezing cold water, her body temperature fell to a record low of 13.7 °C. It took rescuers 80 minutes to cut her loose from the ice, and when they finally managed to resuscitate the 29-year-old woman, her heart had been stopped for three hours. Anna Bågenholm remained in a coma for 10 days and when she woke, was paralysed. But she gradually recovered. Today – 16 years after the accident – her only remaining injury is weak muscles in one hand.

SURGERY REQUIRES 100+ DOCTORS

In two scientific articles from 2013 and 2015, the surgeon explained the head-swap procedure in connection with his ground-breaking experiment. The operating theatre will need to be huge, as the procedure is expected to require up to 150 doctors and nurses. They will be working three shifts during the 36 hour surgery, and two surgical

teams will be working on two different patients at the same time: the body donor – a braindead person, who has donated his functional body to the experiment – and the receiver of the body: Valery Spiridonov, according to plan. Body and head must match as regards blood and tissue types, and the patient must take immuno-suppressing drugs for the rest of his life to prevent the body from rejecting the head. But that, Spiridonov says, is a price he's more than prepared to pay.

Before the surgery, both patients will be anaesthetised, their heads will be locked into position, and doctors start by cutting their heads off. When everything apart from the spinal cord has been cut, the heads are

only connected to the bodies by a 1-cm-thick bundle of nerves. The head of the body donor, which will be given a funeral, is disengaged, and only a few velcro bands prevent its weight from cutting the spinal cord. Spiridonov's head, meanwhile, remains locked to a small "crane".

“The surgery must take place in a country where legislation – or lack of legislation – allows it, and where there are good hospitals. It could be done in China.

When everything is ready, the two teams of doctors hold their breaths, and with perfect co-ordination, they use their ultrasharp scalpels to cut the two spinal cords. Without delay, the crane moves the head to a position right above the donor's body.

CARBON FUSES NERVES

The time that surgeons gain by chilling the patient benefits them when it comes to the next major challenge: connecting the two spinal cords. According to Canavero, the solution is PEG: an organic polymer – long chains of carbon, oxygen, and hydrogen. PEG is well suited to make cells' fat-►

2004 MAN'S ARM ATTACHED TO GROIN

In 2004, Israel Sarrio, a truck driver, had his arm cut off in a traffic accident. The driver's arm was transplanted to his leg and connected to the blood flow of the groin, allowing doctors to combat infections in his shoulder. After nine days, the arm was put back where it belonged, and amazingly, Israel Sarrio regained much of the use of his limb.

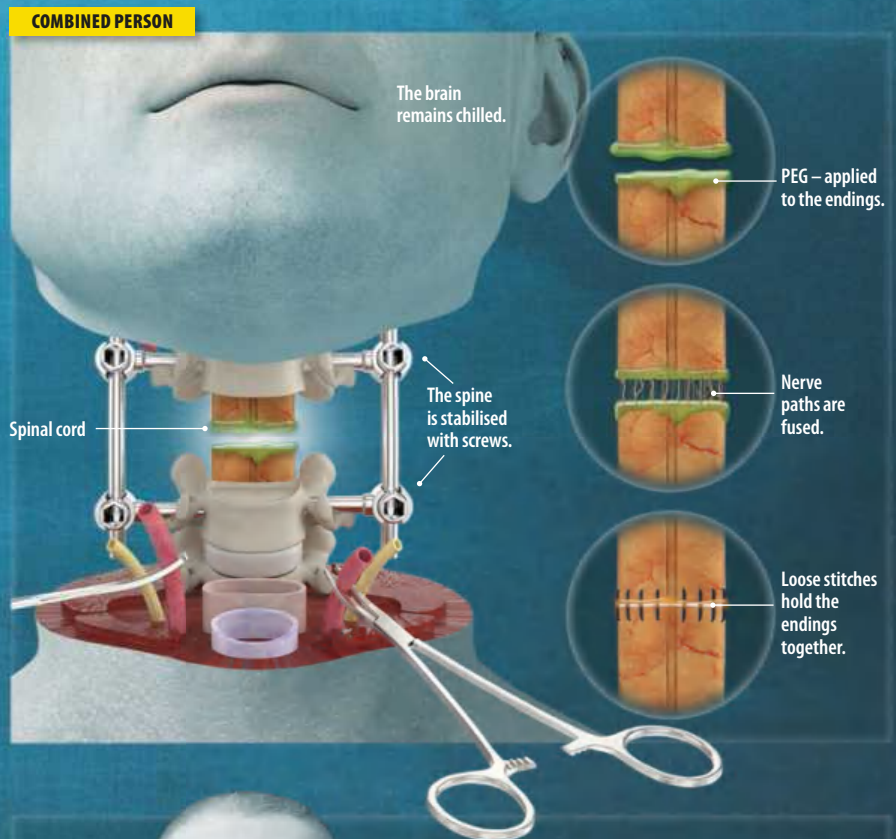


2006 SAVAGED WOMAN GETS A NEW FACE

A French woman was bitten by her own dog, losing the entire lower part of her face. In the world's first face transplant, she was provided with a new lower face: nose, lips, cheek, and chin from a donor.

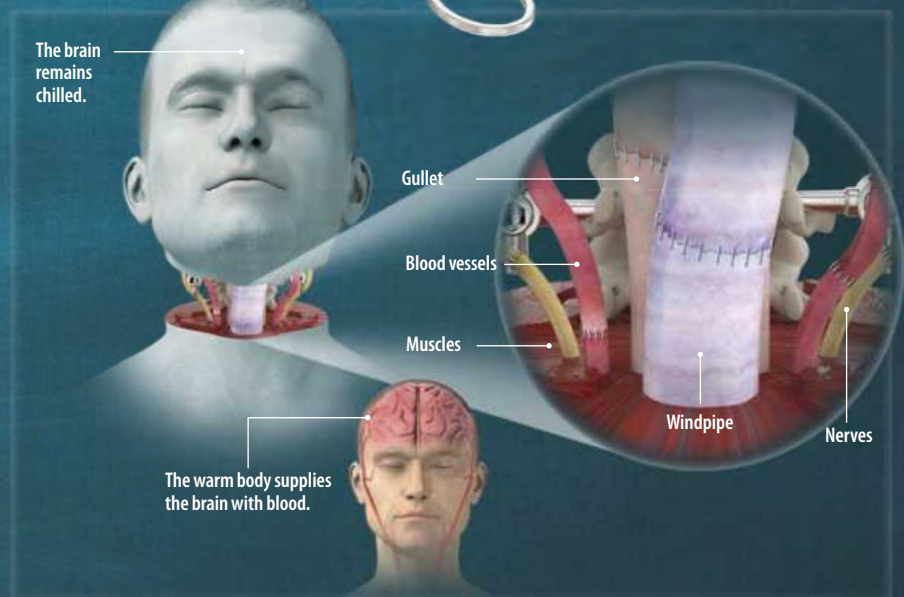
3 Nerve endings are fused

A healing glue consisting of chitosan (sugar) and PEG is applied to the nerves of the two spinal cords. The nerves are placed close to each other, only barely touching in order to avoid pressure damage. PEG makes the nerve cells' membranes fuse, probably because it binds the water located as a barrier between the cell membranes, which contain fat. Without the water, the fat membranes will more easily get in contact with each other. A few loose stitches hold the spinal cords together, allowing the cord to heal. All protective membranes of the spine are sutured together, and the spine is stabilised with screws, clips, and steel wire.



4 Head and body are sutured together

The colour-marked blood vessels, muscles, and nerves are sutured together, connecting the body and the head correctly again. While it is relatively simple to suture the large nerves, the windpipe, and the throat, it is more difficult to connect blood vessels and muscles. In order for the body to function, doctors must meticulously match the right "partners". When the blood vessels have been sutured, the cold head will receive warm blood from the body, slowly returning it to its normal temperature. Finally, the skin is sutured.



AP/SCANNIX

2006 MAN GETS NEW, FUNCTIONAL PENIS

A 54-year-old Chinese man lost his penis in an accident. He soon got a new one from a donor in his 20s, but neither the Chinese man nor his wife could get used to the new penis, and so it was removed again, although it worked both sexually and for urination purposes.



► containing membranes fuse. Scientists regularly use PEG to fuse two cells in connection with gene splicing. Canavero intends to mix PEG and chitosan (a sugar) into a healing glue which is applied to the two cut surfaces. But time is incredibly short: from the moment the two spinal cords have been cut until they have been fused, no more than two minutes can pass.

Hopefully, PEG will seal the junction, but to improve the chances, the Italian doctor is considering also injecting the PEG mixture into the blood vessels of the donor body.

Earlier this year, scientists managed to treat mice with spinal cord injury with nanoparticles covered in PEG. The scientists injected the substance into the spines of the mice, whose legs were partly paralysed. The results showed that mice that had been treated with PEG recovered faster than the ones that did not get the glue treatment.

SHOULD ALL THE NECK BE INCLUDED?

According to plan, Spiridonov's head will be cut off at a low point of the neck, so the head's brain stem is included. The stem protrudes into the very upper end of the neck, controlling basic functions such as breathing, cardiac rhythm, and blood pressure, and Canavero expects that the head's control mechanism will allow Spiridonov the best chances of gaining the use of his new limbs.

According to other scientists, the cut must be made higher up, so the patient gets the brain stem of the healthy body.

This will ensure the "control system" will be compatible with the body.

The brain stem is extremely tough, so although the body donor is braindead, the brain stem may still be functional and able to keep the body alive. One of the supporters of this approach is Xiao-Ping Ren from the Harbin Medical University in China. Together with colleagues, he is one of the first to have

transplants a success, but Valery Spiridonov of course expects an even better result.

"I am afraid, but what people do not really understand is that I do not really have many choices. If I do not try this out, my fate will be very sad. With every year, my situation is getting worse," he explains. Most surgeons agree that the Russian will be risking his life. Such surgery has never

been carried out on humans, and in the very few comparable animal experiments, the animals never regained the use of their limbs. At best, they only survived for a few days. According to critics, the Italian surgeon should test his method on animals first. Xiao-Ping Ren and his colleagues intend to move from mice to monkeys to humans.

Although the risk involved in the surgery seems unnecessarily high, the long-term prospects could be fantastic. If this audacious project is successful, people with rare, disabling diseases such as physicist Stephen Hawking could benefit from the method. And people who are

paralysed in accidents could look forward to having their injured body completely replaced by a healthy one.

Those are the prospects causing Sergio Canavero to go ahead with his radical surgical project, and he is 100 % confident.

"I think we are now at a point when the technical aspects are all feasible," says this self-proclaimed Dr. Frankenstein. He and his voluntary test subject are absolutely determined to go ahead with the first human head transplant in 2017.

We wish them the very best of luck. **SCI**

Headless hen lived for 1.5 years

Several farmers have watched in awe, as their chickens, ducks and even turkeys ran about without heads for up to one minute. The phenomenon is due to nerves only needing the brain to start, stop, and correct motions, and so, chooks can continue running about, until no more oxygen and energy are left. In 1945, an American farmer failed to hit a rooster correctly with his axe, leaving most of the animal's brain stem intact in its body. Even without a head, the stem allowed the bird to live on for another 1.5 years, breathing through its open windpipe.



BOB LANDRY/GETTY IMAGES

The farmer used a pipette to feed the rooster directly into its gullet.

repeated the monkey experiment of 1970 on mice. In 2014, they published a series of experiments, in which 40 mice were given new heads. 18 mice survived head transplants, in which the cut was made so that the brain stem from the body was used. The mice were paralysed, but their breathing and cardiac rhythms were almost normal despite the complex surgery.

SURGERY IS THE LAST CHANCE

The Chinese consider the head

2008

MAN GETS TWO NEW ARMS

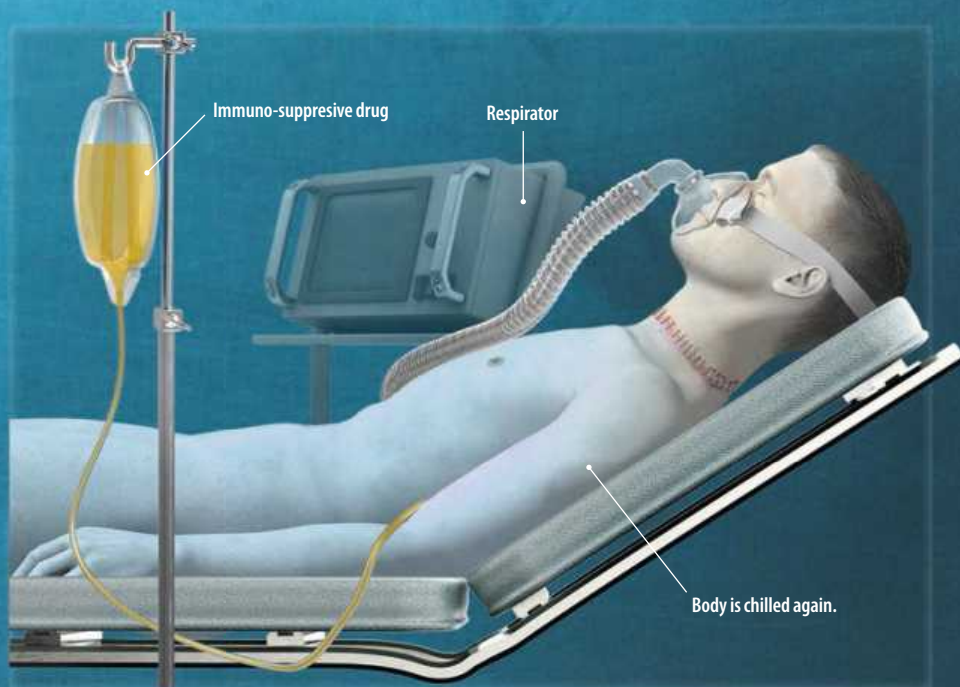
A German farmer lost both his arms in an accident involving his combine harvester. But in a groundbreaking transplant, he was given two new arms from a 19-year-old man, who had died in a car accident. The transplant was successful, but several years passed, before the man could move his new fingers.



ALEXANDRA BEBER/REUTERS/SCANPIX & AP/SCANPIX

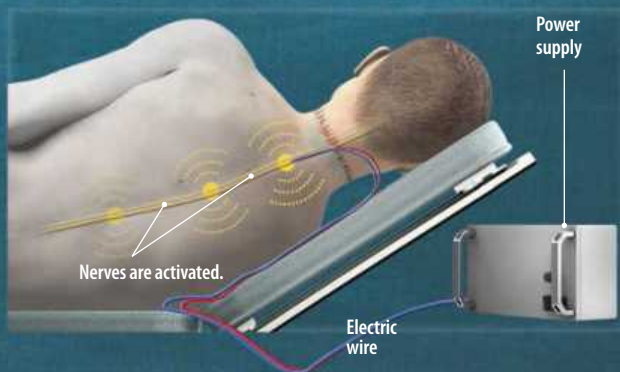
5 Induced coma helps healing

The patient is placed in a medically induced coma by means of medical agents and chilled to a temperature of 33 degrees. The coma ensures that the body and brain lie dormant in total peace, allowing nerve links to heal and regain their ability to send nerve signals. Doctors will provide the patient with immuno-suppressive drugs such as adrenocortical hormone, azathioprine, or cyclosporine. The drugs will prevent the body from rejecting the head. Any rejection may be either acute - the head is rejected in a few hours or days - or chronic, which means rejection could take years.



6 Spinal cord exercised by repeated impulses

During the induced coma, the activity of nerve signals through the spinal cord is insignificant. The nerves are not stimulated and can atrophy. To avoid this, an electrode is introduced into the spinal cord, where body and head are united. The electrode is connected to the nerves and a power supply that produces a series of impulses to "exercise" the nerves.



7 Long rehabilitation to make the body come back to life

If everything goes well, the patient will wake up with the same personality and mental faculties. He is paralysed, but can probably regain the use of his limbs with exercise. He will also need psychological therapy and immuno-suppressive drugs for the rest of his life. In the long term, the major risk is that the immune system rejects the head.



2014

MICE SWAP HEADS

Chinese scientists swapped the heads of mice of different colours. Afterwards, the mice breathed, and their brain waves were normal, but they could not move their bodies and were put down after three hours.



2017-?

PATIENTS GET NEW BODIES

If 2017 becomes the year in which surgeons manage to give paralysed people a new body, disabled individuals will probably be able to regain the use of their limbs. Stephen Hawking could be one of them.





Motion

Spend 10 minutes on the next four pages
and learn more about fundamental science.



By Henrik Bendix



When a rocket lifts off or a billiard ball rolls across the green felt, the same thing is at play: **motion. Any large object in motion acts according to three simple laws, which scientist **Isaac Newton** deduced over 300 years ago. In space, objects stay in motion until they hit something. Here on Earth, friction eventually brings almost everything to a halt.**

“Truth is ever to be found in the simplicity, and not in the multiplicity and confusion of things.”

Isaac Newton

290 KM/H

is the highest speed a skydiver can achieve in a "head down" position. At this speed, acceleration from gravity is cancelled out by the friction of wind resistance.

Your weight is the force with which Earth gravity affects your body, and is determined by your mass. More mass, more downward pull, and thus more weight.



Rocket controlled by laws on Earth and in space

Newton's three laws apply during a space mission – no matter whether the rocket is on the launch pad, accelerating into orbit on a pillar of fire, or drifting through space, where it is almost unaffected by friction.

1st law

An object either remains at rest or continues to move at a constant velocity (speed), unless acted upon by an external force.

The rocket stands still, but an internal tug-of-war is going on. Gravity pulls it down, while the concrete of the launch pad holds it back. If the rocket drifts in space without being affected by anything, it will move at a constant speed.

2nd law*

$$a = \frac{F}{m}$$

Acceleration Force Mass

3rd law

Action equals reaction

In space, the rocket is virtually unaffected by friction. If it is going to change speed, the third law comes into play. If the engine releases exhaust gases at a force of 1 million newtons, the rocket will move forward at the exact same force.



Gravity
↓
↑
Engine power



Gravity
↓
↑
Normal force



* Force equals mass multiplied by acceleration

The rocket accelerates, because the force from the engines overcomes gravity. The acceleration – how fast the speed increases – can be calculated by subtracting gravity from engine power and dividing the result by the total weight of the rocket.

Saturn V's acceleration when launched towards the Moon:

34,500,000 newtons - 27,500,000 newtons

$$\frac{2,800,000 \text{ kg}}{1,120,000 \text{ kg}} = 2.5 \text{ m/s}^2$$

**Did you
know that:**

shoot-outs ...

in most films are unrealistic? In films, the bullet often hits with such force that a man hurtles backwards when hit. If the force were that intense, the shooter would have been thrown back in the exact same way.



Friction robs all Earthbound objects of motion

According to Newton's first law, an object will move at a constant speed only if it is not acted on by an external force. Here on Earth in our thick atmosphere and with our rough surface, the force that will sooner or later make all motion cease is known as friction. The most commonly encountered friction is air resistance. It slows down cars, bullets, and this device known as "Newton's cradle".



1

Air resistance:

The ball is set in motion, but is slowed down. Air resistance is a force that decelerates, and the ball swings back.



2

Internal friction:

When two balls collide, the internal friction converts some of the kinetic energy into heat and sound - a "clink".



3

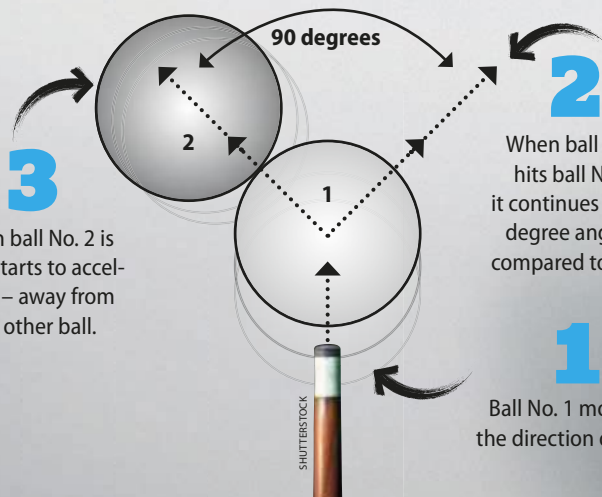
Frictional resistance:

When the balls swing, the threads rub slightly against the rack. This helps slow down the balls and stop the repetition of the swings.



Billiard requires a feeling for physics

When two balls collide on the billiard table, the **90 degree rule** applies. It says that the force is transmitted from one ball to the other at the place where the balls strike each other. The ball which is hit accelerates - like the rocket speeding into space. The balls also affect each other with the same force, only in reverse - like the rocket, which activates its engine in space.



3 When ball No. 2 is hit, it starts to accelerate - away from the other ball.

2 When ball No. 1 hits ball No. 2, it continues at a 90 degree angle as compared to No. 2.

1 Ball No. 1 moves in the direction of No. 2.

The international unit of measure of force is named after Isaac Newton and is consequently known as newton. 1 newton is the force required to provide an object of 1 kg with an acceleration of 1 m/s^2 .

Test (did you pay attention?)

- 1 What is the name of the most famous work of physics?
- 2 Why can't you build a perpetual motion machine?
- 3 What did Galileo Galilei discover?



Answers: 1: *Philosophiae Naturalis Principia Mathematica* by Isaac Newton. 2: Friction cannot be avoided, so sooner or later, the motion will stop. 3: All objects will fall equally fast, if you disregard air resistance.

5

Why motion stops:

Friction from the air and the surface of the ball is the reason that the motion of "Newton's cradle" will not go on forever.



4

Force transmitted:

The central balls do not move, as they pass the motion on to the next one. Only the last ball has room for acceleration.



SHUTTERSTOCK

SHUTTERSTOCK

From Aristotle to rocket car

350 BC >> 1480

Greek philosopher **Aristotle** writes about motion in his work "Physics". He believes that nothing can move without being pushed.



Leonardo da Vinci is obsessed with human flight. His aerial screw is supposed to rise, when the air in the sail is compressed.

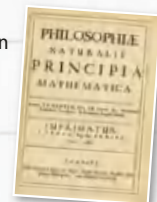


GETTY IMAGES

1638 >> 1687

Galileo Galilei drops objects for science. He demonstrates that all objects will fall equally fast, if they are not affected by air resistance.

English physicist and mathematician **Isaac Newton** introduces his three laws of motion in the most important work in the history of physics: *Philosophiae Naturalis Principia Mathematica*.



SCIENCE

1905 >> 1925

Albert Einstein discovers that nothing travels faster than light – no matter the force applied. This contrasts with the law of motion concerning acceleration. So, Einstein determines new laws for objects that move very fast.



GETTY IMAGES

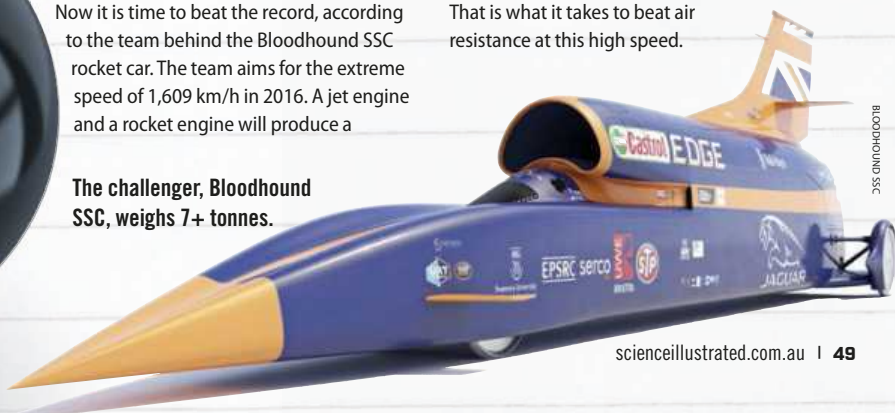
Danish physicist **Niels Bohr** contributes to introducing quantum mechanics – a new set of laws of nature which describe how the tiniest forms of matter move.

2016 Ambitious rocket car

In 1997, the ThrustSSC jet car drove faster than sound, hitting a speed of 1,228 km/h. Now it is time to beat the record, according to the team behind the Bloodhound SSC rocket car. The team aims for the extreme speed of 1,609 km/h in 2016. A jet engine and a rocket engine will produce a

combined force of 212,000 newtons – equal to the total engine power of 180 Formula 1 racecars. That is what it takes to beat air resistance at this high speed.

The challenger, Bloodhound SSC, weighs 7+ tonnes.



BLOODHOUND SSC

METRO-GOLDWYN-MAYER (MGM)



NEW 007 FILM: SPECTRE

Bond receives a message which sends him on a deadly hunt for a mysterious organisation called Spectre.

THE SCIENCE OF BOND

Without his techno-gadgets, James Bond could never have survived 25 films. Cars, weapons, and other equipment repeatedly get him out of trouble. But in 2015, you might be surprised how many of those gadgets have become real products you can buy....

By Antje Gerd Poulsen

REALITY VS FILM

REALITY

REMOTE CONTROL

REMOTE-CONTROL CARS

Many modern cars will park themselves and now, carmakers are going to allow us to remote-control them.

Apple Watch controls BMW and Volkswagen

If you forgot, where you parked your car in a packed carpark, you can now ask it to flash its lights or honk. BMW and Volkswagen have both introduced a remote control app for the Apple Watch, which also allows you to close the windows and sunroof.



Make your car flash its lights, if you cannot find it.



A new app allows you to park your Range Rover using remote control.

App helps you park

Get out of the car, and it goes off to park.

That will soon be possible for owners of new Range Rovers. If you have the company's new smartphone app, ignition key, accelerator, brakes, steering wheel, and gears can be remote-controlled from your phone, allowing a better overall view of any obstacles, so it becomes easier to manoeuvre the big car into

narrow spaces. To avoid accidents, the car is limited to a max speed of 6 km/h, when it is remote-controlled, and it stops all by itself, if the distance between car and driver exceeds 10 metres.

The new app is also useful for cross-country driving, allowing the driver to see the position of the wheels. So far, the app is only a prototype.

FILM

TOMORROW NEVER DIES, 1997

REMOTE CONTROL - Mobile phone steers the car



A cackling 007 hides in the back seat, steering the car via his mobile phone.

Bond runs into a multi-storey car park followed by a group of armed men. He manages to hide behind a pillar, and by using his mobile phone as a remote control, he makes his BMW come pick him up. He jumps into the back seat, from where he steers the car during a wild chase around the car park. The phone display allows him to look through the windscreen, using the arrow keys to navigate. En route, he fires the Bond car's integrated weapon with the remote and finally jumps out, as the BMW flies from the roof of the building.

UTTERLY CRAZY



The Spy Who Loved Me, 1977

FAX WATCH

Bond's watch functions as a kind of smartphone. When headquarters needs to contact the agent, the watch prints a text message on a long slip of paper.

REALITY**INVISIBILITY**

TRANSPARENT TRUCKS

Blind spots cause many road deaths annually, but new technology solves the problem by making vehicles more or less transparent. The "invisibility" makes it both easier and safer to be a motorist.

Truck makes overtake easier

Many traffic accidents happen when cars try to overtake trucks. As the driver of a car located behind a truck cannot see very much, he has to steer into the other lane to see if there is a clear path. Samsung has developed a solution to the problem. The "Safety Truck" system consists of a wireless camera at the front of the truck and a large display at the back. The camera records the road, transmitting images to the display, so the motorists behind the truck can "look" through it. The system has been tested in Argentina.

Land Rover uses a similar technology to make the car's bonnet transparent to the driver. Cameras in the radiator grille are aimed at the space under the car, and the images of the terrain are projected onto the windscreen.

SAMSUNG



You can see oncoming traffic, before you overtake the truck.

WATCH: Screen shows what the truck hides



VIDEO



Samsung has tested the "transparent" truck in Argentina, where accidents caused by unsafe overtaking are a major problem.
youtu.be/6GNGtfse9ZK8

FILM**DIE ANOTHER DAY, 2002**

INVISIBILITY - Bond car 'vanishes'



Bond's car becomes invisible by copying its surroundings.

Bond's Aston Martin V12 Vanquish has a camouflage function, which allows the car to blend into its surroundings. The sides of the car are covered with an LED display, which projects recordings of the background in real time, so the car becomes invisible. 007 uses the function during a car chase inside the crook's melting ice palace in Iceland. Just as the pursuer is about to crash into his Aston Martin, Bond activates the invisibility cloak and speeds up, so the other car collides with a wall of ice instead.

**UTTERLY CRAZY**

You Only Live Twice, 1967

CIGARETTE ARROW

A lethal poison dart is fired at Bond's enemy when the agent lights a cigarette.

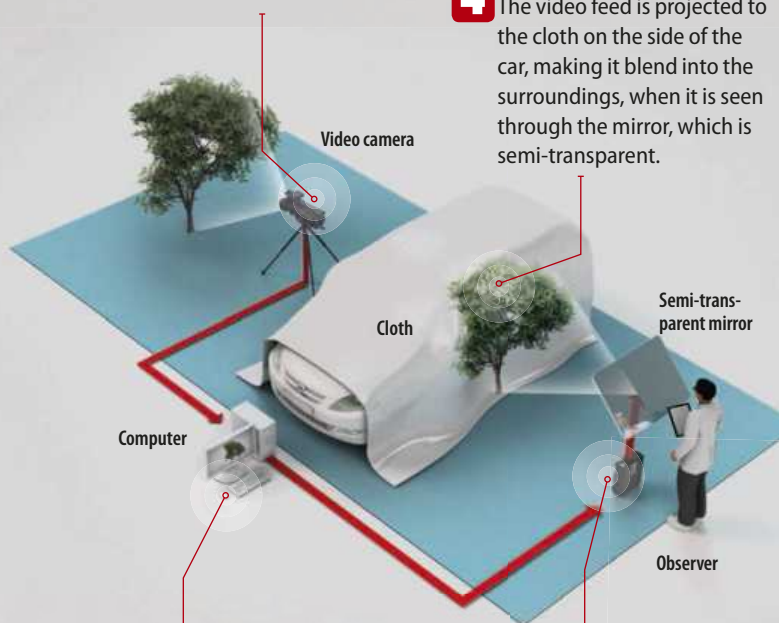
THE KOBAL COLLECTION

CAMOUFLAGE

Cloth makes car invisible

Cars can be made invisible as seen from a certain angle. Known as optical camouflage, the method consists of a camera and cloth on separate sides of the car. It can be used for military purposes.

- 1** At the reverse side of the car – seen from the observer's point of view – there is a video camera.
- 2** The feed is transmitted to a computer, which continuously adjusts the angle and perspective of the images to the observer's position.
- 3** The images are transmitted to a projector and projected to a mirror, which reflects them onto the car that needs to be made invisible.
- 4** The video feed is projected to the cloth on the side of the car, making it blend into the surroundings, when it is seen through the mirror, which is semi-transparent.



REALITY MECHANICAL GILLS

New substance stores oxygen

A South Korean designer has created a diving mask which could allow people to breathe under water without oxygen tanks. Known as Triton, the mask is equipped with artificial gills, which draw water into a chamber and extract dissolved oxygen from the water.

So far, Triton is just a concept, but scientists from the University of Southern Denmark recently created a crystalline substance which may make the vision of the mask come true. The substance attracts and binds oxygen like a sponge and may give it off again as required. Under the right circumstances, 10 litres of the substance can suck up all the oxygen in a room. When the "sponge" has been saturated with oxygen, it is like a diving mask with pressurised oxygen. It can even absorb oxygen from water, and as the sponge absorbs oxygen all the time, it is not necessary to bring oxygen from the surface.

The gill mask is still just a concept, but a newly-developed substance could change that.



FILM

DIE ANOTHER DAY, 2002

UTTERLY CRAZY



The Living Daylights, 1987

SOFA TRAP

When the victim sits down on the sofa, the seat tilts, so he is captured in the sofa. Bond can then sit down on him as a kind of torture.

MECHANICAL GILLS - Small mouthpiece replaces oxygen tanks

Bond's survival kit includes a small mouthpiece with two small oxygen tanks, which can supply him with oxygen for four minutes. When he needs to enter the crook Gustav Grave's Icelandic headquarters, he jumps into the water with the compact diving equipment in his mouth. Then he swims through the freezing water under the ice, finds a hidden entrance, and manages to get in.

The mouthpiece first appears in the Bond universe in Thunderball (1965), in which Bond uses it, when he swims through a basin with sharks.



An oxygen mouthpiece allows Bond to swim a long stretch under the ice.

REALITY

FACE RECOGNITION

Yes, it really works

A newly-developed algorithm can identify people based on photos of their faces taken from oblique angles, even if the faces are turned upside down or slightly blurred. Until now, face recognition has required the photo to be taken from the front, but with the new algorithm, Deep Dense Face Detector, many otherwise useless photos and video recordings will suddenly be useful.

The algorithm, which was developed by scientists from the Stanford University and Yahoo Labs, is based on "deep learning", a type of artificial intelligence by which software learns by the trial and error method. For this purpose, the scientists fed the algorithm 200,000 portraits taken from different angles.



SACHIN PANDAY, MOHAMMAD SADEEN, LIJIA LI

Bond's psyche:

An unscrupulous narcissist and psychopath, according to an American psychologist. The combination is attractive, particularly to women, he says.

SONY PICTURES/SPOL FOTO

Bonds physique:

Blood loss, infections, or cold should have killed Bond, according to scientists, who have taken an closer look at the film Skyfall from 2012. No less than four times during the film he would have died, if he had been made of the same stuff as ordinary people.

92

drinks per week is what Bond consumes, according to a count made by British doctors.

FILM

QUANTUM OF SOLACE, 2008

FACE RECOGNITION- Camera identifies crooks



M16's systems can identify people even when the photos are taken from oblique angles.

During an opera, Bond's opponents communicate by means of discreet earpieces. Bond manages to steal one and hear the conversation. At some point, he intervenes, making the opponents get up, so he can take their photographs. Although the photos were taken from oblique angles, M16 can identify the people in them.

Amusingly, Bond takes photos of the criminals with a now -obsolete Sony Ericsson phone.



SONY ERICSSON

UTTERLY CRAZY



A View to a Kill, 1985

BOAT IN DISGUISE

A small boat camouflaged as an iceberg helps James Bond escape in Alaska. He spends five days on it, in a double bed with a female companion.

MGM

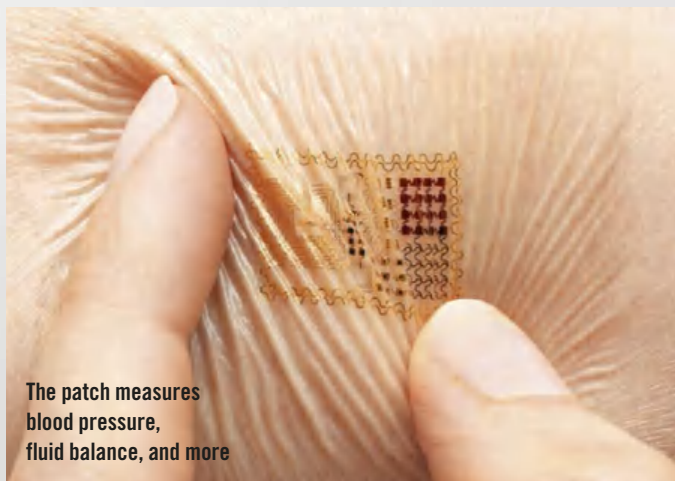
REALITY**IMPLANT**

SMART SKIN PATCH

Today, electronics are so compact that a thin patch placed on skin can monitor our state of health.

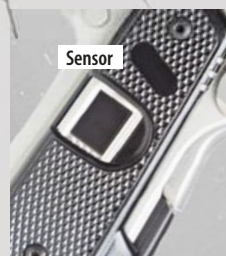
BioStamp is a flexible electronic circuit placed on the skin like a transfer tattoo. The electronic gadget can transmit data wirelessly across short distances such as to a mobile phone, which also powers the patch.

The patch, which monitors a person's state of health, comes in several versions to be used with different diseases. Some versions contain sensors which measure body temperature and hazardous UVA and UVB radiation. Others register acidity, fluid balance, and blood sugar level by using enzymes that react to biochemical changes in the skin. Still others can measure the blood pressure based on the electric capacitance of the skin. Developed by scientists from the Northwestern University in the US, the patch is expected to be available in a few years.



The patch measures blood pressure, fluid balance, and more

MCTO

REALITY**BIOMETRIC ID**

The gun is only unlocked by the owner's fingerprint.

KODIAK

Your unique 'bodyprint'

Last year, the German arms maker Kodiak Industries introduced a sidearm that only unlocks when the owner's fingers are on the handle. Biometric identification is on the rise and no longer limited to fingerprints. Everything from gait to brainwaves can also reveal who we are. The most recent invention is body odour analysis. The method was developed by scientists from the Technical University of Madrid, who believe that our odour will one day be part of our passport ID.



UNIVERSIDAD POLITÉCNICA DE MADRID

The person is identified when an electronic nose sniffs at his hand.

FILM**CASINO ROYALE, 2006**

IMPLANT - Chip monitor's Bond's health



007's chip can be scanned and reveal his state of health.

MGM

A chip is placed under the skin of Bond's arm. Thanks to this chip, M16 can see where 007 is, observe his cardiac rhythm, and scan the contents of his blood. During a card game with the crook Le Chiffre, Bond is poisoned by a drink. Dizzy, he walks to his car and connects the chip to a decoder, so M16 can see which toxin it is. According to the chip, it is the digitalis herbicide, and the London headquarters suggests he use the heart defibrillator in his car.

FILM**DIE ANOTHER DAY, 2002**

BIOMETRIC ID - Personal gun

007's gun can only be used by him, as sensors in the grip recognise his hand. Three green lamps light up when Bond holds the gun in his hand. Otherwise, the lamps are red, and the trigger is locked. During a shoot-out in a high-rise, one of the crooks gets hold of the gun, but the technology saves Bond's life, as the weapon cannot be fired.



MGM

SHUTTERSTOCK

New Zealand is a remnant of a **DROWNED PARADISE**

As much as 93 % of the continent of Zealandia is covered by ocean, and only the highest mountains rise above the Pacific to form what we call New Zealand. New geological surveys prove that this lost continent "sank" over 23 million years ago.

By Niels Hansen

An island as big as a continent, fertile and beautiful, once existed in the middle of the Atlantic. The islanders were direct descendants of Poseidon, the Greek god of the sea, and the capital was rich. But over time, people became ordinary and depraved. Then everything went wrong. Atlantis lost a battle against Athens, and in a single day and night of misfortune, the continent sank to the bottom of the ocean.

The classic version of Atlantis is almost surely just a story, but in the south-western Pacific, an entire continent was indeed swallowed by the ocean. Today, only New Zealand rises above the sea, while 93% of an ancient continent remains flooded. Zealandia, the true lost continent, is 15 times bigger than New Zealand.

Now, New Zealand geologists have a new picture of how Zealandia formed, and why it was eventually lost beneath the waves.

ANIMALS CAME FROM AUSTRALIA

Scientists have known about Zealandia for several years, and they think that the

continent first formed when it split off from the supercontinent of Gondwana 83 million years ago. But very slowly, the continent sank because the part of the crust on which it sat was stretched thinner and thinner. This process slowed 23 million years ago, leaving just a small part of the landmass was above water, and so, scientists used to believe that the animals of New Zealand descended from those of Gondwana.

Now, New Zealand geologist Hamish Campbell has collected biological and geological proof that Zealandia was in fact completely flooded for a short period of time.

If Zealandia totally sank 23 million years ago, as Campbell thinks, the terrestrial animals cannot have survived. They must have gone extinct, as the land shrunk to almost nothing. If so, the animals came from another landmass such as Australia, some 1,500 km west of New Zealand.

In order to estimate whether New Zealand's animals could have immigrated, Hamish Campbell went to the Chatham Islands, 800 km east of New Zealand. Like New Zealand, the islands have a unique flora

and fauna. The geological studies showed that the islands did not rise out of the ocean until some four million years ago, so Campbell concluded that animals and plants can colonize deserted remote areas relatively fast. Meaning that New Zealand's 23 million years is more than sufficient.

ISLANDS WITH ONLY THREE MAMMALS

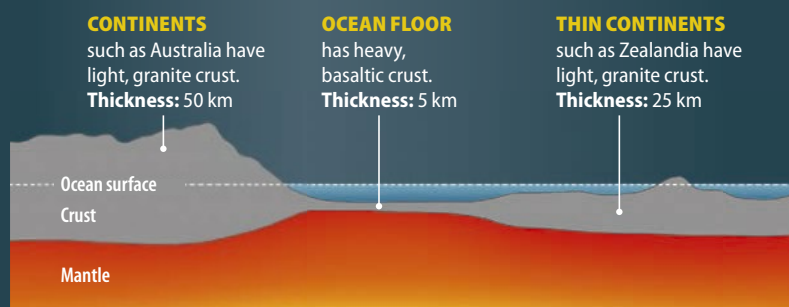
New biological studies also support Campbell's theory. Molecular biologists have collected data showing that at least 95% of all New Zealand species have Australian or South American ancestors – they are not from Gondwana. Other studies show that the majority of New Zealand's animal species emerged during the past 20 million years and that their closest relatives live in Australia.

So, New Zealand could easily have been covered by water 23 million years ago, only to reemerge and become populated by Australian species.

Campbell even has more evidence. Palaeontologists have found dinosaurs on Zealandia. And with dinos, small mammals follow that developed explosively, when the dinos disappeared 65 million years ago. But apart from three bat species, New Zealand has no natural mammal population. Campbell knows why. The animals sank with the continent. **SCI**

Ocean covers Zealandia

Earth's surface consists of two different types of crust: ocean floor crust and continental crust. They float on the mantle below like trees float on water. While the ocean floor crust is thin and dense, the continental crust is thick but light. Only thin continental crust, which Zealandia is made up of, does not rise above the ocean surface.



Geological butchery drowned Zealandia

Zealandia has a long and violent geological history, in which tectonic forces pushed and tore at the small continent until it drowned.

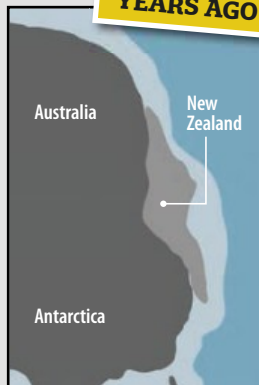


Subduction zone: The plates move under each other



Spreading zone: The plates move away from each other

**200
MILLION
YEARS AGO**



1 A single great continent

While the dinosaurs roam Earth 200 million years ago, Zealandia is still part of the supercontinent of Gondwana, which is made up of many of the modern continents.

**83
MILLION
YEARS AGO**



2 Zealandia breaks away

A mid-ocean ridge forms in eastern Gondwana, producing new ocean floor crust. As new ocean floor is produced, the small continent is forced away from the rest of Gondwana.

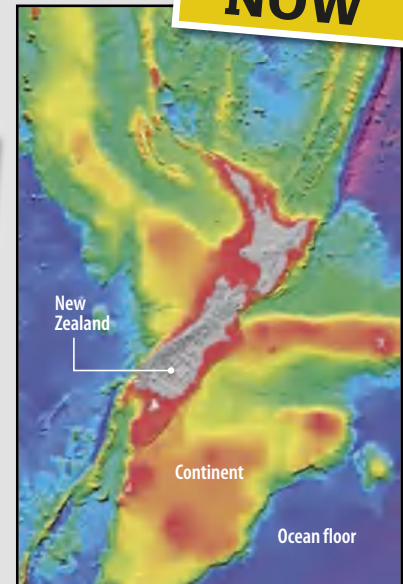
**23
MILLION
YEARS AGO**



3 The crust thins out

50 million years ago, along the eastern side of Zealandia, a subduction zone is formed that pulls the crust into the mantle. The crust thins so much that Zealandia is lowered and floods.

NOW



4 New Zealand is all that remains

22 million years ago, the tectonic forces of the region change direction. Over time, plate collision forces a small part of Zealandia to appear above the ocean surface: New Zealand is reborn. Today, NZ is still very tectonically active with volcanoes and up to 18,000 earthquakes a year.

23 million years ago, New Zealand was covered by water. Only three mammal species, all bats, are part of the islands' natural population today.



1 September

1859

156 years ago, the most violent solar storm in history hit Earth with incredible force. We were at the mercy of...

CORBIS/ALL OVER

◀ Past and...

The Fury of the Sun

On 1 September 1859, the Sun unleashed a massive flare that struck Earth. The energy of the storm was the equivalent of 10 billion nuclear warheads. Even in those days, humans felt its immense force, as auroras lit southern skies, and telegraphs struck sparks.

By Andreas Ebbsen Jensen

Low on the horizon, the Sun appears like a ripe orange in the sky on 1 September 1859, as Richard Carrington steps into his private observatory. Outside, the late morning light showers his beautiful country estate, and the 33-year-old Englishman is glad that he is not in hectic, noisy London. It is a perfect day for dusting off his telescope and taking a look at the bright Sun, which has fascinated him all his life.

Carrington opens a small roof trap and focuses the telescope at the surface of our life-giving star. At first, there is nothing unusual to be observed, but after a few minutes, the amateur astronomer stares at the image in awe. A series of white, kidney-shaped dots explode forcefully, and Carrington feverishly reaches for his notebook to draw a sketch of the surprising phenomenon.

10 BILLION BOMBS

At this point in time, he has absolutely no idea that he is the first person to witness the most violent solar storm ever recorded. But 17 hours later – on the night of 2 September 1859 – the rest of the world also becomes aware of the solar eruption. It has sent tonnes of red-hot gases out of

the Sun's atmosphere in a so-called coronal mass ejection, which carries the same energy as 10 billion detonated nuclear bombs. And when the cloud of heated gases hits Earth's magnetic field, a magnetic storm is triggered, which lights up the dark of night.

Two thirds of the planet is lit by auroras of red, green, and purple colours, which can be observed as far south as in Cuba and Hawaii. In several places, birds start to sing, and in the Rocky Mountains, a group of gold-

diggers get up, as they think morning has come. In north-eastern USA, confused citizens also get out of bed to read the paper by the light of the auroras. But not everyone is equally thrilled about this rare and extraordinary phenomenon.

FEAR OF DOOMSDAY

Everywhere in Europe and the US, telegraph systems start to fail due to the geomagnetic storm that sweeps the world. Sparks fly from the telegraph apparatuses, setting the paper on fire, and in several cases, telegraph operators get electric shocks.

The extreme magnetism caused by the solar storm briefly puts several regions of the world in a situation reminiscent of the ten biblical plagues. The skies and the oceans turn blood-red, and monster waves measuring several metres roar towards the coasts, causing problems for ships at sea. The most god-fearing earthlings have no doubt: Doomsday has come. The end of the world is near.

Luckily, it was not that bad after all. Less than 24 hours after Richard Carrington observed the white dots through the lens of his



Richard Carrington watched the solar eruption from his private observatory.



CITY OF VANCOUVER

Telegraph lines failed in Europe and the US. Today, a solar eruption would cause much more infrastructure breakdown.

Present ▶

If such a solar storm hit Earth today

A solar storm of the same intensity as the one Richard Carrington observed in 1859 would have much worse consequences today. Many mobile phones, computers, and GPS systems

would fail, causing a communication breakdown, which could black out cities for months. According to American scientists, a solar storm of such magnitude would cause damage and destruction worth over \$2 trillion.

telescope, the solar storm subsided, and Earth went on the same as ever. Eventually, the violent solar flare became known as the Carrington event, and the eruption remains the most severe ever recorded. Today, scientists can predict solar storms 2-3 days before they take place by taking a look at the Sun's internal magnetic fields. And data

centres and similar sites protect themselves against major solar eruptions using many sophisticated techniques, such as layers of metal to shield against extreme magnetism. If the huge solar storm had hit us today, it would have taken years to repair the major damage inflicted on our sophisticated electric networks. **SCI**



In 2012, we were extremely close to being hit by a huge solar storm.

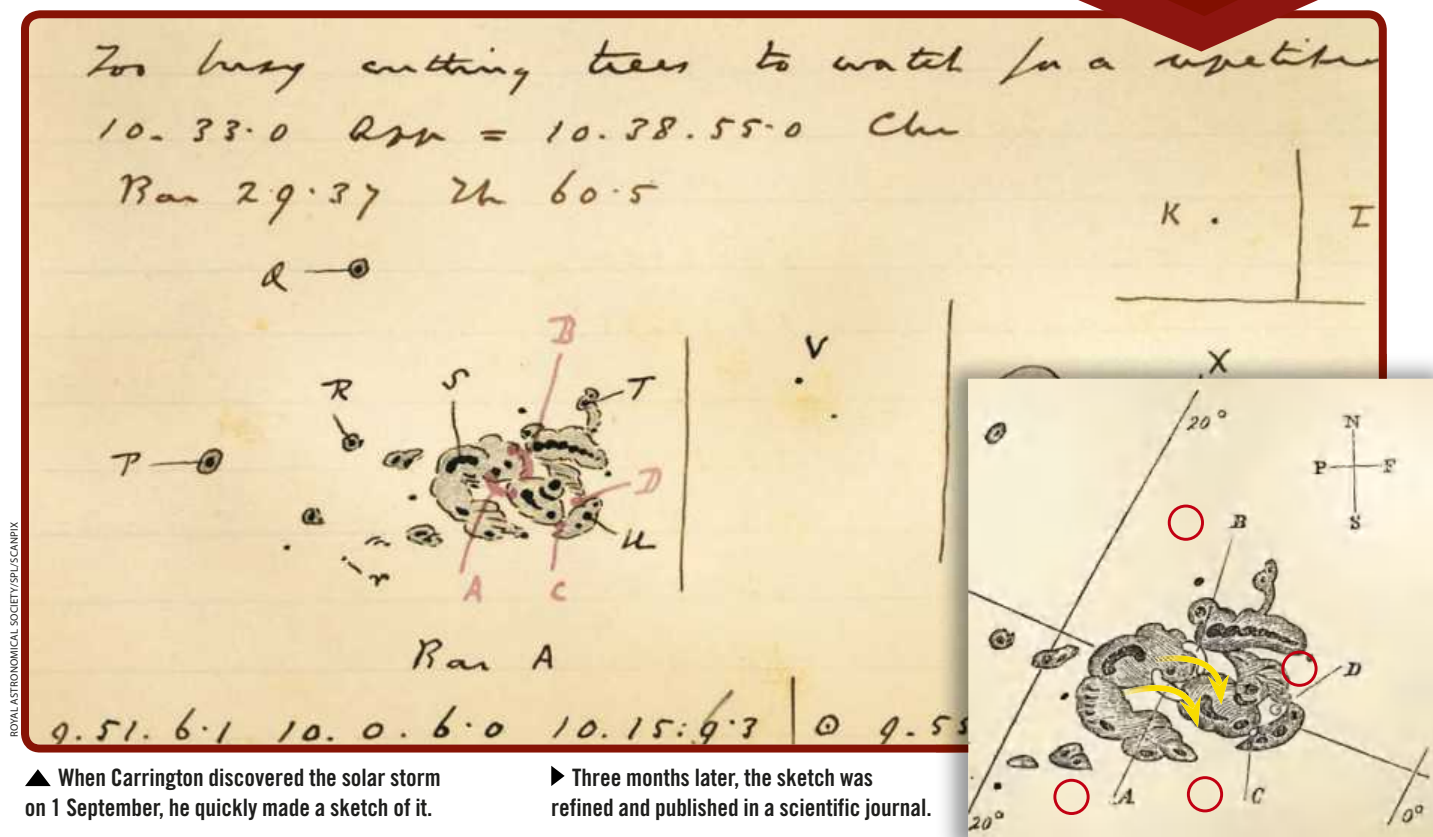


Auroras occur, when solar storms hit Earth's magnetic field.

A flare to end all flares

Richard Carrington made a sketch of the intense activity on the surface of the Sun on 1 September 1859. Points **A** and **B** indicate the sunspots, which lit up first in Carrington's telescope. In the space of just five minutes, the bright sunspots travelled 55,000 km across the surface of the Sun, before shrinking into small spots (points **C** and **D**). Carrington first thought that his observations were due to dirt on the lens. They were the real thing.

FOCUS ON THE DETAIL



▲ When Carrington discovered the solar storm on 1 September, he quickly made a sketch of it.

▶ Three months later, the sketch was refined and published in a scientific journal.

SONIC SHAPE

CREATED IN THIN AIR

Using a brand new method, scientists have created ultrasound shapes, which can be touched in mid-air. The technology can remove physical buttons from sound players, and in the future, surgeons can touch a tumour scan before they operate.

By Mikkel Meister

You are at a rock concert. The speakers produce a heavy, steady bass sound. Not only do you hear the oscillating sound waves of the music – you also clearly feel their pressure as a thumping in your chest, and in your gut.

The compression waves of sound can be felt on skin, and scientists from the University of Bristol have used the phenomenon to create invisible 3D shapes, which can be touched by fingers in mid-air. Instead of deep bass frequencies, the scientists use ultrasound, which oscillates thousands of times per second. The ultrasound allows them to create small points in the air, in which the sound is sufficiently intense to be felt on skin.

In the future, scientists aim to create detailed shapes of objects, allowing a surgeon to feel a virtual 3D scan of a cancer tumour before surgery, so he will know exactly where and how to cut.

SPEAKERS PRODUCE SHAPES

Scientists have named the technology

ultrahaptics. It is a sophisticated version of haptic feedback, which has been used for years to make joysticks vibrate and provide computer games with a more life-like experience. Haptic feedback is also experienced in the buzzing of smartphones, as your finger hits the letters of the keyboard. But by moving the vibration into mid-air, scientists have taken haptic feedback to a new level, which has required both technical and mathematical skill.

The central element of the scientists' prototype is a grid of 320 small speakers or transducers. From there, the ultrasound is projected and manipulated, producing small, accurate, vibrating focal points in the air about 20 cm above the speakers.

A human being with a good sense of hearing can perceive frequencies of 20-20,000 Hz, sound waves that oscillate 20- 20,000 times per second – or from a very deep bass to a high treble. Ultrasound cannot be heard by humans, and in this case, the scientists use ultrasound of around 40,000 Hz to create the small vibrating points in the air.

If all the speakers projected ultrasound at the same time, the result would be vibrations everywhere in the air above them. But via mathematical calculations, scientists can find out how much the sound waves must be offset to collide and amplify each other in one predetermined, perceivable focal point.

By creating more focal points at the same time, the 320 transducers can so far create simple geometrical shapes. Several times, test subjects have been able to feel cones and cylinders, though they cannot see them with the naked eye. As the technology is refined, ultrahaptics may be used to project a 3D CT scan into the air, so it can be touched.

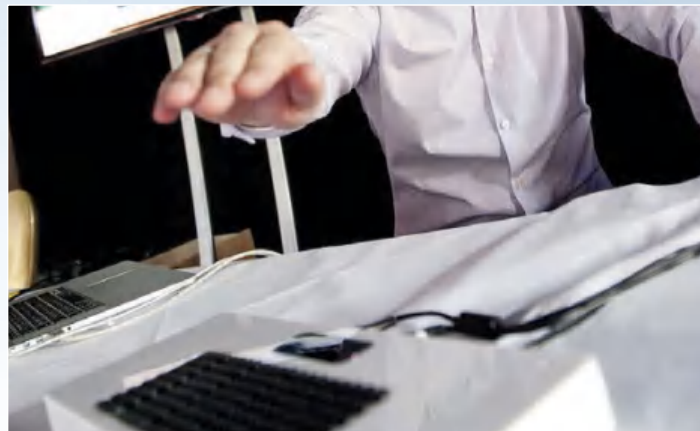
HIT THE BUTTON WITHOUT TOUCHING

The main objective of ultrahaptics is to create sophisticated user interfaces such as music players that can be operated without touching real buttons or touch displays.

So, on top of the transducers, there is a canvas, which allows the ultrasound to pass from beneath. Moreover, the top side of the canvas can produce an image via a projector. By linking the device to a computer, scientists have managed to create simple user interfaces such as a sound player whose music can be played by “hitting” a focal point in the air above the image of the play button on the canvas.

In the future, virtual buttons, etc. will be able to prevent, say, chefs leaving greasy fingerprints on the surface of a cooktop. And with ultrahaptics installed in a car, the driver will be able to operate the radio, air-conditioning system and more without needing ugly buttons all over the wheel. **sci**

320 speakers produce an invisible 3D ultrasound figure, which can be touched 15-20 cm above the surface.



Sound waves collide in mid-air

Ultrasound can be used to create virtual objects in the air. Scientists manipulate ultrasound waves to collide in specific places, and the result is a tiny, concentrated vibration in mid-air, which your fingers can 'feel'.



Invisible music controls
youtu.be/2QkbVr4J7CM

Sound waves are focused.



20 cm

Sound waves interact and are amplified in one common, vibrating point.

3

The offset waves amplify one another in the very point, in which they all collide, producing a perceivable vibration.



10 cm

Sound waves start interfering, but are still scattered.

2

To concentrate the vibrations into specific points, the frequencies are projected at intervals. The phenomenon is known as phase offset.



0 cm

Ultrasound waves are projected in offset.

4

By creating several focal points in the air at the same time and at different altitudes and depths, scientists can build 3D objects and make CT scans perceivable.



BRISTOL UNIVERSITY

The ultrasound 3D shapes are visible when projected into oil.

1

The heart of the system is a grid of 320 small speakers, known as transducers, projecting ultrasound.



BRISTOL INTERACTION AND GRAPHICS

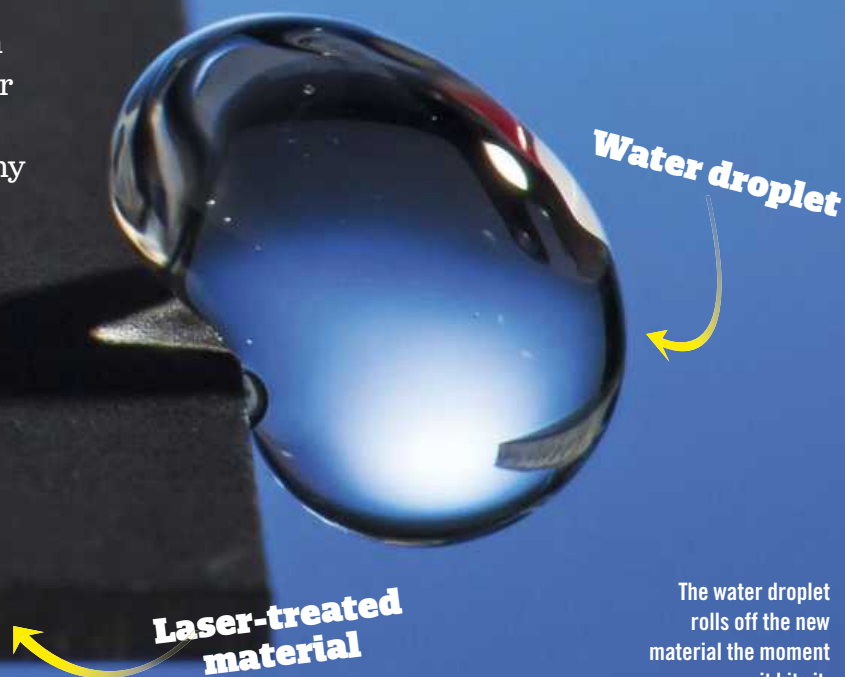
320 small speakers project ultrasound waves.

CLAUS LUNAU

Everything bounces off new supermaterial

Soon, you will no longer need to wash your car, worry about bacteria in your food, or even flush the toilet. A new laser treatment method means that any liquids will bounce off this water-repellent surface structure, and the waterproofing will not wear off.

By Gorm Palmgren



J. ADAM FENSTER/UNIVERSITY OF ROCHESTER

The scientist releases a droplet of water from the pipette, making it fall onto the coal-black piece of metal. As the droplet hits the metal, it deforms, but instead of spreading across the surface like a wet film, it collects and bounces off the material like a ball without leaving the least bit of moisture. The metal cannot get

wet, and, moreover, it is very easy to clean. When water droplets roll across the water-repellent surface, they collect and remove all dust and dirt in the process, leaving the surface spotless. A light shower replaces a car wash after a ride on muddy forest roads.

THOUSANDS OF PULSES PER SECOND

In 2015, physicists Chunlei Guo and his colleague Anatoliy Vorobyev from the University of Rochester, New York, developed a new laser treatment method, which creates water-repellent surfaces. A nonstick frying pan with a teflon surface must be tilted to an angle of almost 70 degrees before water droplets roll off, but with the new metal surface, a tilt of just four degrees is enough. The big difference is due to the

water droplet resting on the laser-treated metal like a fully inflated ball, ready to roll off. Teflon is much less water-repellent and causes the water droplet to form a semi-inflated ball, which sticks to the surface.

The secret behind the new surface is an extremely powerful laser, which very accurately engraves a special pattern into the metal. The so-called femtosecond laser is discharged in pulses lasting 0.000000000000065 seconds, making the energy discharge extremely concentrated. At a rate of 1,000 pulses per second, the laser beam makes tiny bits of the metal evaporate, producing small dents in the surface. The special effect is obtained thanks to a double pattern: First, a row of parallel grooves are engraved 0.1 mm apart, and subsequently, the laser makes the surface of the grooves

WATCH: See water bounce off lasered metal



Drops thrown by a new laser treated material so that the car of the future will not rust, and the toilets work without water.

youtu.be/FLegmQ8_dHg

New material solves everyday problems

Water and other liquids bounce off the new laser-treated metal, so toilets require less water, cleaning becomes obsolete, and cars will not corrode.



Ice will not form on aircraft wings

1 When rain freezes on aircraft wings, the aerodynamic qualities are destroyed, putting air safety at risk. Droplets will bounce off laser-treated wings before freezing.



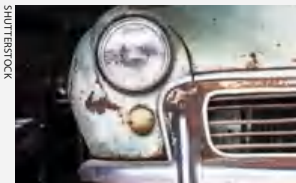
Toilets require almost no water

2 If toilets and drain pipes are made of laser-treated metal, very little water is required to rinse them; a huge advantage in countries with water shortage.



Medical gear and water pipes become sterile

3 Bacteria in water pipes or on medical equipment make up a health risk. But the microbes can be prevented by the new metal, as a few water droplets will remove them.



Cars and bikes will not corrode

4 A car or a bike made of the laser-treated metal will never corrode, as the surface is always dry. In rainy weather, the water droplets will immediately roll off the surface.

knurled by producing grooves with diameters of only 0.000005-0.00001 mm.

Guo and Vorobyev have tested the laser treatment on three different metals: platinum, titanium, and brass. Each metal requires that the laser be adjusted to fit its qualities in order to obtain the right groove pattern. For instance, platinum requires three times as much energy as brass. Although scientists know that uneven surfaces tend to be water-repellent, they do not know for sure why the special double pattern is so efficient.

They are also surprised that right after the laser treatment, the metal can be wet - it only becomes water-repellent after first having brief contact with air.

Other scientists have created almost as water-repellent surfaces by applying a type of paint to them, but over time, the water-repellent layer will rub off. We know the phenomenon from teflon frying pans, to which food will not stick for the first couple of months, but which then lose this ability. That will not be the case with Guo's and Vorobyev's new method, as the laser treatment changes the structure of the metal surface, so the water-repellent qualities will always remain with the material.

Today, it takes one hour to laser-treat a piece of metal of 2.5 x 2.5 cm, but the scientists aim to improve the technique, so the treatment can be carried out much faster and cover much larger surfaces.

**0.00000000
00000065**

**seconds: the duration of each
laser pulse producing the
water-repellent surface**

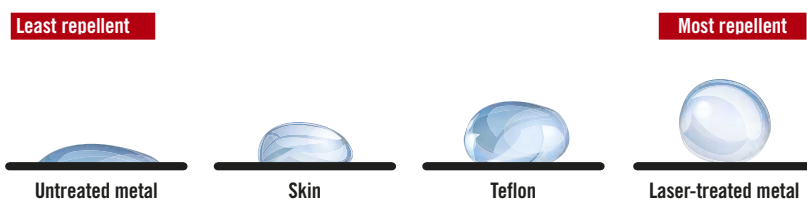
The knurled grooves of the surface also make light rays get "lost", when they are reflected back and forth between the small grooves, so they are not reflected again. The metal surfaces appear coal-black, and they absorb almost any light. This is useful in connection with solar panels or water tanks, which harvest electricity or heat from sunlight.

The two scientists have shown how incredibly easy it is to keep the laser-treated metal surfaces clean. In an experiment, they placed the contents of an ordinary vacuum cleaner bag on a piece of the water-repellent metal, subsequently tilting the metal 8 degrees and applying water droplets one by one. Amazingly, after just three droplets of water, half of the dirt had been "collected" and removed, and after 12 droplets, the metal was completely clean - and dry.

Guo and Vorobyev now intend to find out whether the method can also be used on other materials. If so, we may one day forget everything about washing our dishes and clothes - and about wearing waterproof clothes. **sci**

Droplet settles like a bubble on the surface

When water droplets hit water-repellent materials, they are deformed, collecting into balls with very little contact with the surface. On the new laser-treated material, the droplet keeps its circular shape, rolling off the metal.



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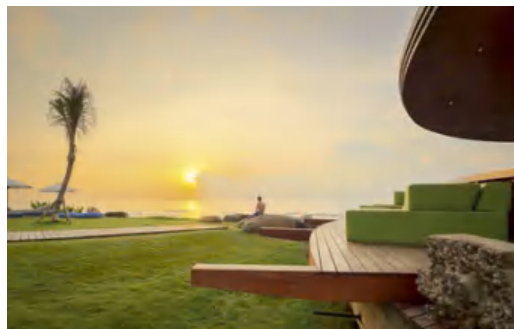
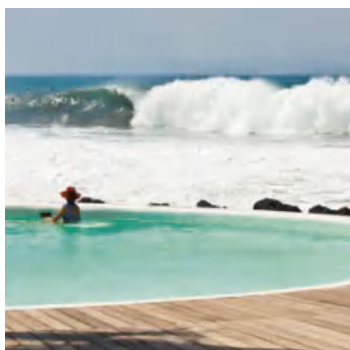


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ULTIMATE ANIMAL

BEAKS, JAWS, AND CLAWS MAKE AWSOME HOMES

Humans aren't the only living creatures who appreciate great design. Some of the best architects in the world are to be found among the animals, that build geometrically-perfect and even air-conditioned dwellings. The superb architects of the animal kingdom use nature's own raw materials for their designs, which are modestly built of branches, paper... or their own poop.

CLAUS JUNAU & SHUTTERSTOCK

Topic	BEAVER LODGE	Project	DAMMING	Scale	1:100
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By Stine Overbye



ARCHITECTS

Beavers are landscape architects who make sure that their dens are protected by water.





Beavers build sheltered homes in the water

Beavers cooperate on cutting down trees and building dams, flooding huge woodlands. A recently discovered dam is so huge that it can be seen from space.

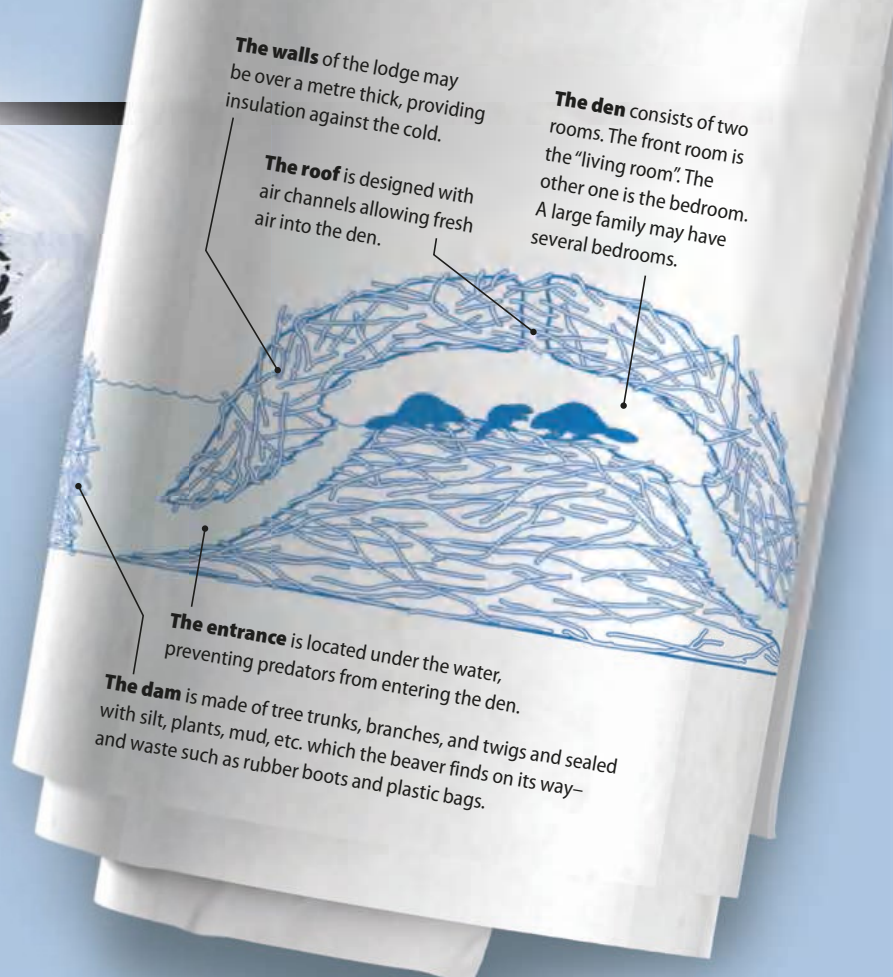
Beavers are capable landscape architects, specialising in reshaping nature according to their own needs. By felling trees and building dams, the furred engineers change the landscape completely.

The rodents protect their homes against predators by placing the entrances to the dens under water. Consequently, they build their lodges by lakes or streams, and if the water is not sufficiently deep, the rodents build dams, causing the water level to rise. As a result, huge areas are flooded, so the den entrances are protected and it is easier to

carry wood to them by water.

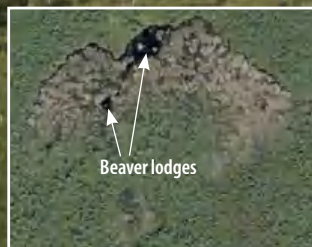
The biggest beaver dams are up to 500 m long, but in a remote, inaccessible corner of the Northern Alberta National Park in Canada, beavers have built a dam that beats all previous records. The structure measures some 850 m, making it more than twice as long as the famous American Hoover Dam.

The Canadian beaver dam, which was spotted on Google Earth in 2010, is so big that it can be seen by satellites.



DAM AND DEN

- **Materials:** Branches, tree trunks, silt, mud, and waste
- **Inhabitants:** Beavers
- **Site:** Europe, North America
- **Location:** Woodlands with lakes and streams



The 850-m-long beaver dam in Northern Alberta, Canada, can be observed from space.

GOOGLE

Weaver ants use larvae as glue guns

Most ants remain on the ground, but weaver ants prefer penthouses. The ants' nest is the size of a beach ball and hangs down from tree tops. The worker ants that build the nest are only 5-10 mm long, which is not much, when the ants collect huge leaves before the weaving process begins. The ants cooperate to handle the job, hooking up with each other in chains, one ant's jaw "embracing" another

one's waist. In this way, hundreds of ants can produce a 20-m-long rope, allowing them access to the leaves

Subsequently, the foliage is glued together with glue guns – the ants' own larvae, which, unlike the adults, produce silk. The worker ant holds on to a larva with its jaws, moving it back and forth along the leaf edges, until they stick together.



The ant larvae produce silk, which is used to stitch the nest together.

WOVEN ANTS' NEST

- **Materials:** Leaves and silk thread produced by ant larvae
- **Inhabitants:** Weaver ants
- **Site:** The tropics of Australia, Asia, and Africa
- **Location:** Leaf-bearing trees

Social housing for birds

From a distance, the nest looks like a haystack which is about to fall from a tree. But when you move closer, you will see a fancy, woven bird society, whose inhabitants live together in pairs throughout the year in their own nests with their own entrances. The huge sociable weaver nest accommodates up to 100 families or a total of some 400 individuals, and it is so sturdy that

numerous generations can benefit from it: With maintenance, the nest can last for more than 100 years.

The biggest sociable weavers' nests are six metres wide and three tall, weighing up to several tonnes. Inside the nest, the birds live side by side in an apartment building with 10-15-cm-wide chambers lined with soft plants, fur, cotton, and down. At the bottom

of each flat, there is a private entrance: a 25-cm-long tunnel protected by a sort of barbed wire in the form of sharp straws.

If the sociable weavers maintain their housing block, it may last for 100 years.



BIRD SOCIETY

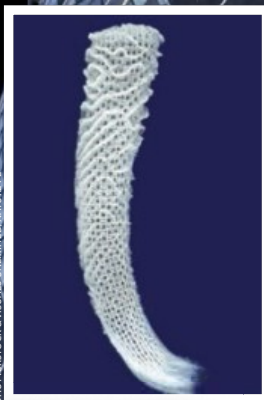
- **Materials:** Twigs and grass
- **Inhabitants:** Sociable weavers
- **Site:** The savannas of South Africa, Botswana, and Namibia
- **Location:** Trees with high-hanging branches or telephone poles, etc.

BIOMIMICRY

Nature is full of ingenious ideas which have been tested and developed over millions of years. Human inventors have successfully taken inspiration from peculiar deep-sea animals, sticky plant seeds, hairy feet and more.

London skyscraper copies deep-sea sponge

When British architect Norman Foster designed London's new landmark, the 180-m-high office block 30 St Mary Axe – also known as the Gherkin – he took a good look at the Venus' flower basket deep-sea sponge. The cylinder-shaped organism's skeleton is made of glass-like splinters which make up a glittering grid of hexagonal cells. As well as providing strength and flexibility, the skeleton efficiently filters out microorganisms from the ocean water for the sponge to feed on. In Foster's skyscraper, the filtering qualities are used to save the cost of an airconditioning system. At the street level, air is sucked into the Gherkin through flue funnels, and subsequently, the air circulates upwards through the skeleton, cooling the structure.



The deep-sea sponge's skeleton is made of hexagonal cells.

OTHER INVENTIONS INSPIRED BY NATURE



■ **SUPERGLUE** is inspired by the hair on the feet of geckoes, enabling them to climb vertical walls.



■ **THE SPEEDO FASTSKIN** is inspired by shark skin, whose texture reduces turbulence and water resistance.



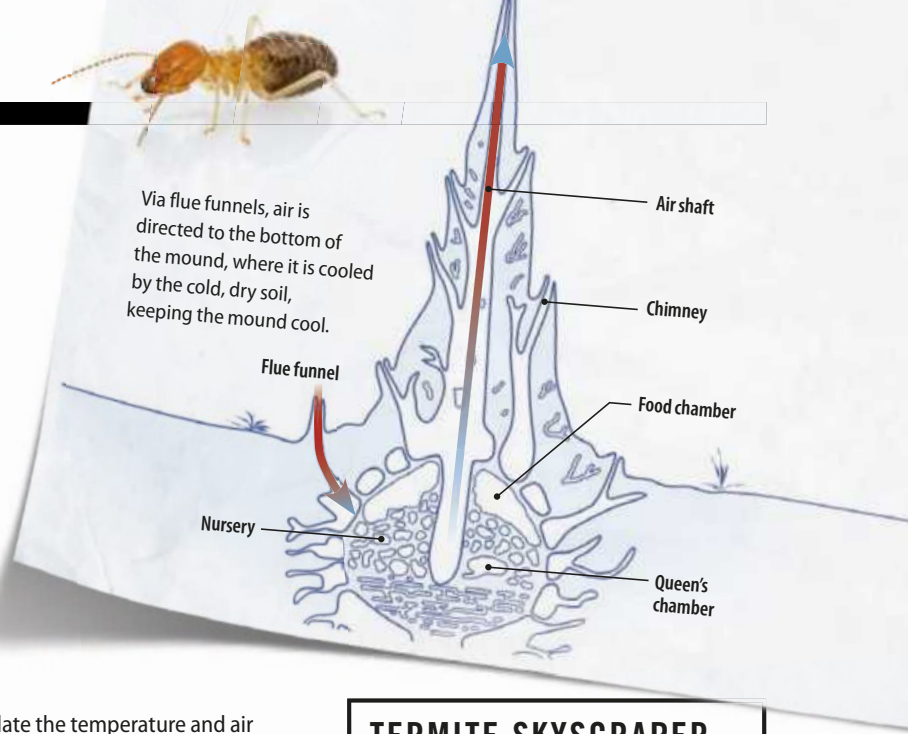
■ **VELCRO** was inspired by burdock seeds, which stuck to the inventor's dog.

Termites build airconditioned cathedrals

Like endless rows of medieval churches, the 6+-m-tall clay structures built by cathedral termites rise above Australia's dry plains.

Termites are experts on extensive and ingeniously designed building projects, and one of the species that excel in the discipline is the cathedral termite. Its towering structures, inhabited for 50-100 years, are made of a mixture of soil, chewed plant parts, faeces, and saliva. From the outside, the mounds seem like some of the most spectacular in nature, and on the inside, the cathedrals are even more impressive. Beneath the rock-solid shell, the mound features a very efficient airconditioning system with air shafts and vent holes,

which regulate the temperature and air humidity. The system makes sure that the 2-3 million inhabitants benefit from a constant indoor climate of some 30 degrees – although it may be much warmer or colder outside. Moreover, the system provides ideal growth conditions for the fungi that the termites grow. The fungi are extracted from plant material and grow in gardens which provide the busy termites with food.



TERMITE SKYSCRAPER

- **Materials:** Soil, plant parts, faeces, and saliva
- **Inhabitants:** Cathedral termites
- **Site:** Northern Australia, Africa
- **Location:** Savanna woodlands

African shopping centre inspired by termite mound

The Eastgate Centre in Zimbabwe's capital of Harare has an airconditioning system similar to the termite mounds'. Thanks to the termites, the shopping centre only consumes one tenth of the energy compared to other buildings nearby. At night, cold air is sucked in at street level, and as temperatures rise during the day, the air flows through floor plates, cooling the structure at no cost.

As the air heats up during the day, it is directed out through the chimneys.

INGO ARNDT/MINDEN PICTURES & PHILIMON BULAWAYO/REUTERS/SCANPIX





Prairie dogs build underground cities

On the vast grasslands of the US and Canada, prairie dogs roam huge cave system cities which they dug using their sharp claws. The cities can be spotted from afar due to the cone-shaped ramparts of soil surrounding the entrance holes. The ramparts resemble

chimneys and function as ventilating systems and watch towers, where one or more prairie dogs keep watch, as their family members search for food.

The rodents live together in complex families of one male and up to five females that have their own tunnel system in the city. The colonies typically consist of some 1,000 prairie dogs and are often passed on from generation to generation, growing ever bigger. An ordinary colony covers an area of 1.3 km², but some cities are much bigger. The biggest known city was located in Texas and boasted an area of 65,000 km² and had around 400 million inhabitants.

Guards will yap loudly, if predators or competitor dogs approach the colony.

ROLF HICKER/GETTY IMAGES & SHUTTERSTOCK

UNDERGROUND CITY

- **Material:** Soil
- **Inhabitants:** Prairie dogs
- **Site:** USA, Canada
- **Location:** Prairies and steppe regions, preferably with running water in the vicinity

Wasp makes paper nest

Long before humans ever thought of writing down their ideas, wasps had invented paper. Chewed wood chips mixed with saliva are converted into dome-shaped dwellings.

Mouthful by mouthful, the paper wasp builds its nest. Using its mandibles, it gnaws bits of wood off tree trunks, mixing them with saliva to produce a soft, sticky, papery material, which is both light and strong.

The wasp builds its nest, spitting out the paper mass and moulding it into a cone-shaped dwelling with hexagonal cells for the larvae. When the papery material has hardened, it is firm and sturdy. The paper is not only

waterproof, it can also both absorb and release heat, ensuring a constant temperature inside the nest.

The hexagonal shape of the cells combines strength with efficient space utilisation. As new generations of wasps grow and hatch, the nest is expanded to match the number of inhabitants. The adult wasps keep on adding new larval brood cells, while guards persistently protect the nest and its thousands of inhabitants.



The papery material is waterproof.

Brood cell

The floors are connected by beams.

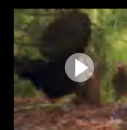
Hexagonal brood cells strengthen the structure.

Horizontal floors made of cell cakes



The male collects dozens of blue objects. Carrying a plastic ring in his beak, he dances to impress the female.

WATCH: These birds sure think they can dance!



Bowerbirds do not just decorate. The male also performs an elaborate dance to further impress his potential mate.

youtu.be/U89tw093s_Y

Bird attracts mates with grand home

Bowerbirds are true decorating experts, and when the male is looking for a mate, he spares no effort to outcompete his rivals with pomp and style. Bowerbirds do not have permanent mates, and the male does not help the female with nest-building, brooding, or raising the offspring. The only thing he contributes is his genes, and so, the females are extremely picky when they choose a partner. In his efforts to attract a mate,

the male makes a love-nest in the shape of a bower. In front of it, he lays out a stage which he decorates with flowers, berries sorted out by colour, and more. Some species make a type of maypole of sticks instead of a proper bower. The pole may top two metres and be decorated with ornaments made of bug poop. When a female is impressed by the male's masterpiece and lands by the bower, he performs a dance, and they mate.

IMPRESSIVE HOME

- **Materials:** Moss, feathers, acorns, flowers, dead insects, glass, bones, cans, plastic, and beer bottle caps
- **Inhabitants:** Male bowerbirds
- **Site:** New Guinea, Australia
- **Location:** Forests and scrub



The larvae are fed chewed caterpillars, flies, and other insects.

NURSERIES

- **Materials:** Wood chips and saliva
- **Inhabitants:** Paper wasps
- **Site:** In most of the world, particularly the tropics
- **Location:** Forests, scrub, and near homes or other places with roof eaves

TONGUES: THE LONG, THE SHORT AND THE BIZARRE

Lions use theirs to get ready to hunt, woodpecker tongues protect the birds against concussions, and chameleon tongues accelerate faster than a fighter jet. In the animal kingdom, tongues are multipurpose tools that ensure survival.

By Kristian Filrup



NATURE PL & SCANPIX & SHUTTERSTOCK

Acacia trees on the African savanna are full of thorns, but giraffes do not care.



Leathery tongue protects against thorns

The small shoots of acacia trees are the favourite food of giraffes. But the shoots are difficult to access, as the tree hides them behind a thick cover of long, pointed thorns.

Nevertheless, the tall animal wraps its 50-cm-long tongue around the shoots time and time again, feasting on them. The surface of a giraffe tongue is full of small, hard knobs known as papillae, which provide the tongue with a leathery exterior resembling a shoe sole: hard, flexible, and impenetrable.

Still, the tall animal will inevitably get thorns in its mouth, but a thick layer of saliva protects the giraffe's mouth, ensuring that the thorns do not harm the mucosa as they pass through the digestive system. The saliva-coated thorns are not broken down by digestive enzymes, rather they are vomited.

The giraffe tongue is outside its mouth most of the time. The animal consumes a few hundred kg food per week, which is collected by the tongue. To ensure that the organ is not burnt by the sun, the tongue is coloured by melanin, making it dark and protecting it against the bright sunlight.



Through two holes in the palate, pheromones are sent towards the vomeronasal organ and the brain.

Snake "sees" with taste



Snakes have nostrils and are able to smell in the same way as most other animals. But in addition, snakes use their tongues to smell 'images' of their surroundings. For this purpose, the reptiles use their vomeronasal organ. Many animals have the organ which is used to detect pheromones and determine whether a female is in rut.

Snakes use the organ to "taste" the air. The cleft tongue shoots out of the mouth and picks up smell particles. When a snake retrieves its tongue, it transfers the particles to two holes in its palate, sending them on to the vomeronasal organ, which analyses the smells and sends the data to the brain. The snake gets a snapshot of where the smell comes from and what the surroundings look like.



Barbs keep fur clean



Impurities in the fur can trap smell and betray a big cat as it sneaks up on its prey. So, it is important for the predator to keep its fur clean. Cat tongues are equipped with small barbs made of keratin – the same material that nails and hair consist of. Like a comb, they are used to remove dirt from the fur.

Cats spend about half their waking hours licking their fur to remove impurities. For this purpose, the barbs are terrific, but at the same time, a lot of hair ends up in the cat's stomach. The result is one of the distinctive characteristics of felines: hair balls, which are vomited all the time.



Giant fish crushes prey



Measuring more than three metres, the arapaima is one of the biggest freshwater fish in the world, and in its mouth, it carries a devastating weapon.

The big fish belongs to a small group known as bony-tongues. As the name implies, the arapaima is equipped with a tongue made of bone. On the top surface, the tongue is studded with small jags reminiscent of teeth. The fish catches its prey by opening its mouth, sucking water and prey into it with great force. The arapaima uses its tongue to crush the prey savagely against its hard palate, which also consists of bone.

When the chameleon tongue hits its prey, skin flaps on the tip of the tongue are wrapped around the animal, fixing it.

JOSE B. RUIZ/NATURE PL



41G
IS THE FORCE WITH WHICH
A CHAMELEON TONGUE
IS CATAPULTED.

Accelerates faster than a fighter aircraft

Chameleons in search of food shoot their tongues towards the unsuspecting prey... and with incredible force.

Despite of its slow gait, the chameleon is an efficient hunter, not least due to its tongue, which is catapulted towards the food.

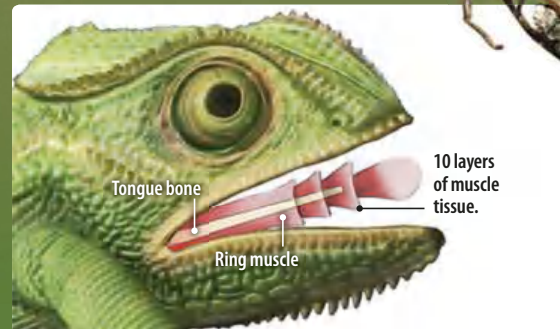
When the sophisticated tongue acts out its death blow, it happens with violent force. In 1/16 of a second, the tongue accelerates to 20 km/h – or an acceleration five times more forceful than that of the latest jets.

The tongue consists of tissue layers placed on top of each other like a telescopic antenna. At the core, you will find the tongue bone. When a chameleon attacks its prey, it flexes its tongue muscles. Due to the shape of the bone, the tongue shoots out and “unfolds”.

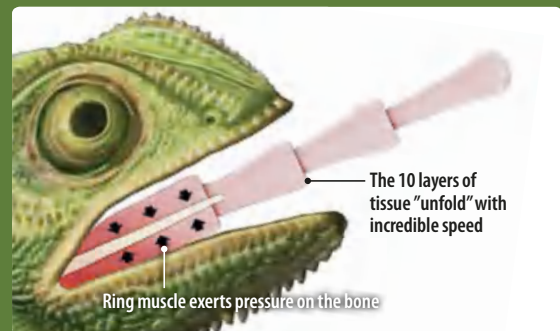
To reduce friction, the space between tongue and bones and between the individual tongue layers is full of liquid.

The combined effect of muscle, lubrication, and structure has power equivalent to a 40kW motor. To ensure the best possible chance of success, the tip is equipped with skin flaps, which wrap around the prey on contact. The prey is snared as the tongue is withdrawn.

Ring muscle catapults tongue



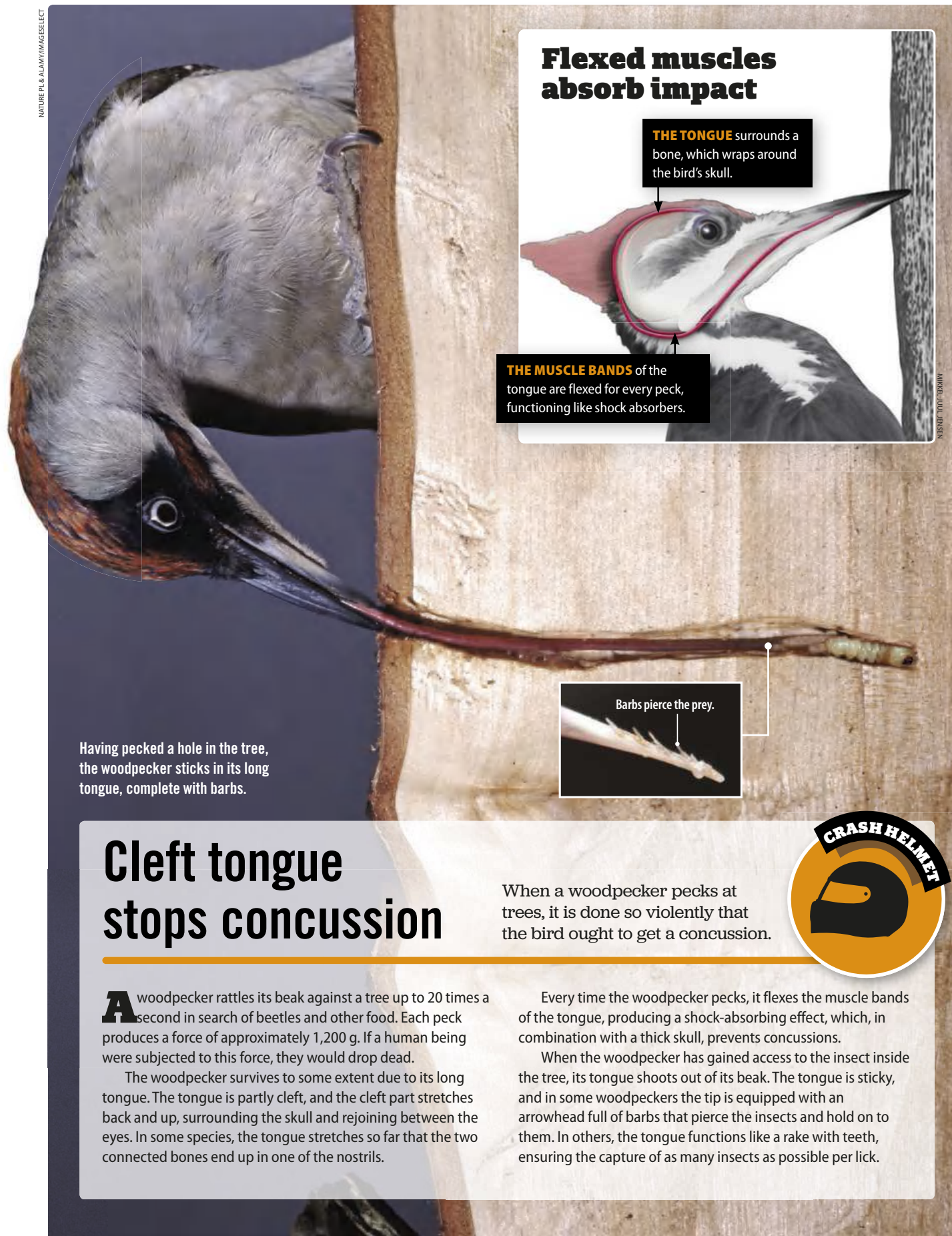
1 The tongue consists of 10 layers of tissue surrounding the tongue bone. When the tongue is at rest inside the mouth, the layers are “compressed” like a telescopic antenna.



2 The ring musculature of the tongue tissue exerts huge pressure on the bone, when the tongue is catapulted. The shape of the bone makes the tissue layers of the “antenna” unfold.

SHUTTERSTOCK

MARKEL JULL JENSEN



Flexed muscles absorb impact

THE TONGUE surrounds a bone, which wraps around the bird's skull.

THE MUSCLE BANDS of the tongue are flexed for every peck, functioning like shock absorbers.

Barbs pierce the prey.

Having pecked a hole in the tree, the woodpecker sticks in its long tongue, complete with barbs.

Cleft tongue stops concussion

A woodpecker rattles its beak against a tree up to 20 times a second in search of beetles and other food. Each peck produces a force of approximately 1,200 g. If a human being were subjected to this force, they would drop dead.

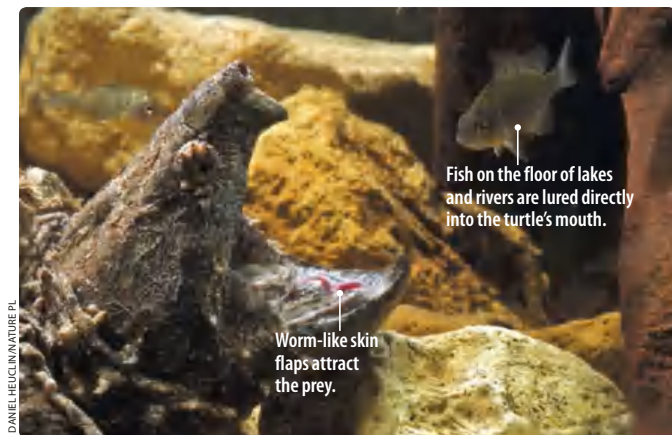
The woodpecker survives to some extent due to its long tongue. The tongue is partly cleft, and the cleft part stretches back and up, surrounding the skull and rejoining between the eyes. In some species, the tongue stretches so far that the two connected bones end up in one of the nostrils.

When a woodpecker pecks at trees, it is done so violently that the bird ought to get a concussion.

Every time the woodpecker pecks, it flexes the muscle bands of the tongue, producing a shock-absorbing effect, which, in combination with a thick skull, prevents concussions.

When the woodpecker has gained access to the insect inside the tree, its tongue shoots out of its beak. The tongue is sticky, and in some woodpeckers the tip is equipped with an arrowhead full of barbs that pierce the insects and hold on to them. In others, the tongue functions like a rake with teeth, ensuring the capture of as many insects as possible per lick.





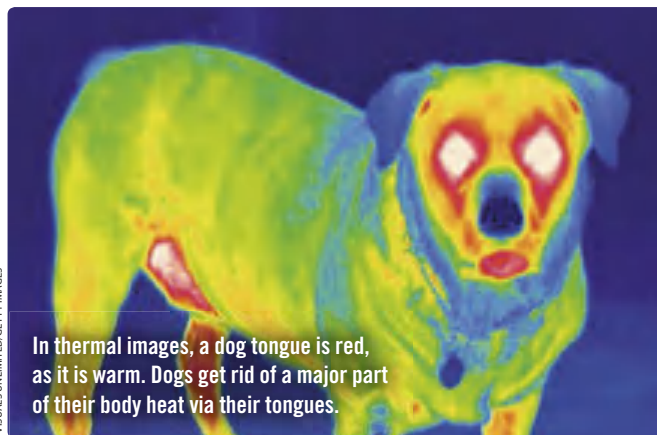
DANIEL HEUCHE/NATURE PL

Turtle lures food into its mouth

The alligator snapping turtle is one of the laziest hunters of the animal kingdom. The turtle lives on the floor of rivers and lakes, and it rarely hunts its prey—the food goes to its death willingly.

The hungry turtle opens its mouth, wriggling its tongue slightly. Most of the tongue is the same colour as the rest of the turtle, but at the tip, there are two red skin flaps. As the turtle moves its tongue, the skin flaps resemble tasty worms.

When a fish has been lured into the trap, the turtle just needs to slam its powerful jaws shut and enjoy the meal.



VISUALS UNLIMITED/GETTY IMAGES

Panting stops dogs from overheating

A dog's sweat glands are located around the paws and on the snout, but they are too few and small to allow the dog to get rid of all its surplus heat. So, dogs gasp with their tongues sticking out of their mouths. The moisture on the tongue evaporates, cooling the dog. In addition, the fast breathing helps water from the surface of the lungs evaporate and cool.

In spite of frequent gasping, dogs may still run into problems on a very hot day. Flat-nosed breeds have difficulties panting properly, subjecting their tongues to sufficient quantities of air, and all breeds risk losing too much water from the tongue on hot days.



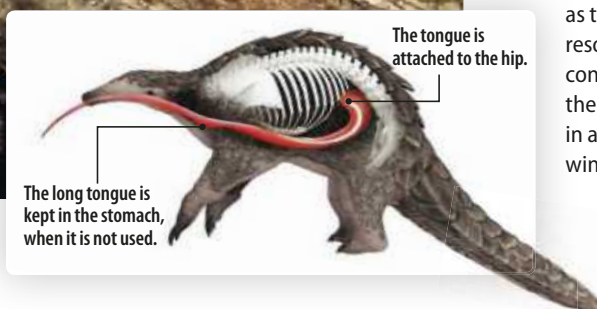
Pangolin is shorter than its tongue



The pangolin, which will grow no more than a metre long, can make its tongue protrude 40 cm from its mouth, while the majority of the tongue is still inside its body. In most pangolins, the tongue is longer than the animal itself.

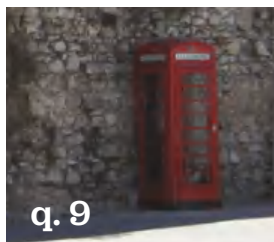
The long tongue is an advantage when termites and ants are collected and consumed. But length is not enough. In order to make the insect meal stick, the tongue is covered in sticky saliva, which functions like fly paper. Pangolins can consume as many as 100 ants per minute, when attacking a nest.

The large organ requires lots of room, and as the animal has no teeth, it must resort to other means. The muscles that control the tongue are attached around the hip, and the tongue itself is stored in a cavity of the stomach between the windpipe and the breastbone.



TRIVIA

PUT YOUR KNOWLEDGE
TO THE TEST



q. 9



q. 4

1. Which power-boosting car engine technology is named after the Greek word for "wake" and the Latin for "spinning top"?
2. What is special about the group of snails and slugs called the "pulmonata"?
3. Asterion is the proper name of which mythological creature, trapped in a labyrinth, half-man and half-animal?
4. Where can you find the Archibald Fountain?
5. Where can you find a famous artificial waterway called "The Serpentine"?
6. What is the common name of the island, one of the most remote on Earth, famously known by the nickname "The Navel of the World"?
7. Which South American mammal, with unusually tough skin, probably caught leprosy from 15th century European explorers?
8. What doesn't the Sovereign Yidindji Government officially recognise, despite being located within Queensland?
9. Where can you find a classic red English telephone booth on the Spanish peninsula?
10. According to the International Union for the Conservation of Nature, when it comes to endangered species, what is the difference between "EW" and "EX"?

ANSWERS ON p82!

Trivia Countdown (use fewer clues, get a higher score!)

	5 POINTS	4 POINTS	3 POINTS	2 POINTS	1 POINT
1. BOTANY Name this herb	This green herb is rich in wholesome substances such as folic acid, antioxidants, and vitamin K.	The herb plays an important role in Middle Eastern cooking. It is used in the Lebanese salad "Tabbouleh".	The Latin name of the plant genera is Petroselinum. Several species exist, such as crispum.	Usually the leaves of the herb are used in cooking. But the root, which resembles horse radish, is also used.	The present name of the herb is derived from petersilie (Old English) and peresil (Old French).
2. GEOGRAPHY Name this big city	It is a city of almost 700,000 people, and it is located at 43 degrees N and 18 degrees E.	In spite of the Cold War, this Eastern European city hosted the Winter Olympics in 1984.	The name of the city originates from the Ottoman way of saying "Field of the Court": Saray Ovasi.	Gavrilo Princip shot Archduke Franz Ferdinand in this city, an act which triggered World War I.	Today, the city is the capital of Bosnia and Herzegovina. It played an important role in the civil war of Yugoslavia.
3. FICTION Name this comic series	The first instalment was published in 1963. It was the brainchild of Stan Lee and Jack Kirby.	The series is famous for tackling sensitive topics such as racism, prejudice, and bullying.	It is about a group of people known as Homo superior, who obtain super powers via mutation.	Since 2000, seven films based on the books have been made, and more are in production.	Characters include Wolverine, Storm, Cyclops, Rogue, Jean Grey, Magneto, Mystique & Iceman.

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HOVERFLY

Scientific name:

*Simosyrphus grandicornis***Distribution:** Throughout eastern Australia**Status:** Common

PHOTO: MEGAN POWELL



NATIVE BEES?

We mentioned native bees in the main text, and indeed Australia has many species of true bee. While the introduced honeybee dominates, these little fellows, the Blue Banded Bee (*Amegilla cingulata*) contribute to the pollination of at least 30% of Australia's crops. Rather than living in hives, the males of this species sleep on plant stems, while the females dig burrows to lay eggs.

TO BEE, OR NOT TO BEE?

A number of factors - a little bit of rain, a good laying season last year - have combined to create a veritable explosion of hoverfly numbers around Sydney in 2015. These small but ubiquitous insects are swarming in clouds of thousands wherever flowers bloom, and are often mistaken for "native bees" or indeed honeybees.

In fact they are harmless to humans and are true flies, not bees at all. Bees are part of the superfamily Apoidea, and have four wings. Hoverflies belong to the superfamily Syrphoidea and have only two main wings. Their rear wings have adapted into so-called halteres which work like gyroscopes and keep the insect level in flight.

Both honeybees and hoverflies rely on flowers and their nutrient-rich nectar and pollen. But rather than evolve complex

stings and venom, hoverflies have instead simply come to mimic the distinctive yellow and black patterns most predators associate with stinging bees and wasps. It takes a brave (or knowledgeable) human to grab a stripy, buzzy bug that's dipping its tongue into a flower!

Hoverflies are of course named for their sophisticated flight, where incredibly rapid and controlled wing movements (as well as information on wind speed and angle of attack from the halteres) allow them to hang almost stationary in the air. Even compared to the mighty dragonflies, hoverflies are fast and stable fliers.

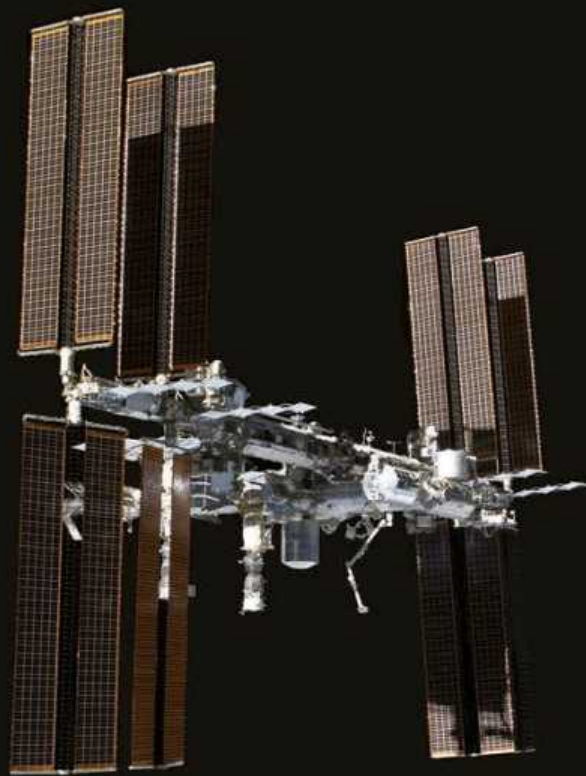
Entomologists have recently discovered that some hoverfly species are predators themselves, and actually eat the larvae of aphids and thrips. These pests can destroy entire crops and cause billions of dollars in

damage a year worldwide, so we're coming to see the hoverflies as important allies in the war on other bugs.

In this amazing photo - captured with a mobile phone, if you can believe it! - a hoverfly rests on a seed pod in the Blue Mountains, west of Sydney. Dew clings to its distinctive compound eye, a huge wrap-around organ which gives it excellent situational awareness, if not particularly good detailed vision.

Hoverflies are completely harmless, and do not have a sting, nor do they bite. So you can quite safely get up close and observe them drinking nectar or eating pollen. They are useful members of the garden ecosystem, and are a sign that you have healthy plants. And this year, there are millions of them! **SCI**

TRIVIA ANSWERS: 1. The turbocharger. 2. They can breathe air and live on land. 3. The Minotaur. 4. Hyde Park, Sydney. 5. Hyde Park, London. 6. Easter Island. 7. The Armadillo. 8. The Commonwealth of Australia's sovereignty over their land. 9. On Gibraltar. 10. EW is Extinct in the Wild, and EX is confirmed Extinct. **Trivia Countdown:** Name this herb: Parsley. Name this big city: Sarajevo. Name this comic series: X-Men



THE SKY IS NO LONGER THE LIMIT.

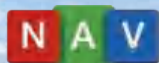
The screens of the Future are available today!

Screen Innovations has worked with NASA to develop a one-of-a-kind, ambient-light-rejecting, zero-gravity screen to be installed in the International Space Station...

Until now, astronauts on the International Space Station communicated with Mission Control and their families back home on tablet-sized 13-inch displays. Now they will have a large roll-out screen from Screen Innovations, together with a laser projector that should last more than 30,000 hours of use – that's a movie a day for more than 40 years.

The criteria for a screen in space were unique, from the obvious need for extreme lightness and easy storage to trickier requirements such as screen rigidity in zero gravity and the ability to reject the bits of food and other detritus that have a habit of floating around zero-gravity environments.

Although the theatre in your home resides in a more-worldly environment with picture quality taking a front row seat it's nice to know that Screen Innovations also delivers the best down-to-earth solution around.



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